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REPORT OF THE ENTOMOLOGIST

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., September 20, 1925.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1925.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. W. M. JARDINE,
Secretary of Agriculture.

DECIDUOUS-FRUIT INSECT INVESTIGATIONS

Investigations of deciduous-fruit insects have been carried out under the direction of A. L. Quaintance, as formerly.

PEACH INSECTS

Work on peach insects has proceeded mainly along former lines. Anticipating the availability July 1, 1925, of an increase of \$10,000 for a study of the oriental peach moth, work on this insect was begun early in May by the employment of an entomologist especially competent in this investigation. Headquarters for the work were established at Riverton, N. J., in a district where the insect is prevalent and destructive. This pest is also being studied at the Fort Valley, Ga., laboratory. The work at the latter station has shown the insect to develop four or five broods of larvæ each summer in that region. Fortunately commercial orchards in Georgia have not yet been invaded to any extent, and the potential destructiveness of the insect, in view of the removal of its food with the harvesting of the Elberta, a midseason variety and the latest peach commercially grown, has not yet been ascertained.

During the late summer and fall of the year 1925, through cooperation with the Federal Horticultural Board, considerable attention was given to the determination of the present dis-

tribution of the oriental peach moth. Briefly the insect has been found in the District of Columbia and in the following States: Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Indiana, Louisiana, Maryland, Mississippi, New Jersey, New York, North Carolina, Pennsylvania, Tennessee, Texas, and Virginia. Sufficient work has not been done in the Mississippi Valley States, New York, and Michigan to determine whether it is present to any extent. Nursery inspectors cooperated during the fall of 1925, but few discoveries of the pest were made. Further observation on the insect confirms former conclusions that its severity may be expected to vary considerably from season to season, owing principally to the influence of its insect parasites, of which some 15 have already been found. The investigations under way in New Jersey and Georgia, it is hoped, will develop a method of satisfactorily controlling the pest, or at least of greatly reducing its damage.

In connection with the plum-curculio investigations continued for some years at the Fort Valley, Ga., laboratory, where various studies are under way in cooperation with the Bureau of Plant Industry of this department and the Georgia State Board of Entomology, what is apparently the first dusting of fruit orchards by airplane for the control of an insect pest was accomplished at Montezuma, Ga. About 100,000 trees were under experi-

ment, some of which were treated by airplane and some by means of ground power dusters. By means of the air dusters it was possible to apply the combined insecticidal and fungicidal dust very rapidly, and about 5,000 trees were dusted per hour, including the time required to return to the landing field and reload the outfit. The final results from airplane-dusted peach trees as compared with the results from trees dusted with ground machines indicate practically as good control of the curculio from the airplane as by the ground duster. Numerous details, however, remain to be worked out in connection with the dust itself and the feeding apparatus of the duster to make the work of the highest possible effectiveness.

In connection with the extended life-history studies of the curculio under way for some years at the Fort Valley station, observations were made on the winter mortality of the insect as influenced by the character of the hibernation quarters. Beetles confined in cages with bare ground showed a mortality of 88.3 per cent; with oak leaves in the cages, 64.1 per cent; with pine needles, 48.4 per cent; and with Bermuda grass, 36.3 per cent.

Studies of paradichlorobenzene for the peach borer, especially to determine the age of trees to which the chemical may be safely applied, have been continued at the Fort Valley, Ga., and the Vincennes, Ind., laboratories; at the latter place in cooperation with the Purdue University Agricultural Experiment Station. At the Vincennes station it appears possible to treat with safety peach trees much younger than those which can be safely treated in the Fort Valley region. In the former district nurserymen are taking up the treatment of blocks of trees with fairly satisfactory results. In connection with these studies, attention is being given to the determination, by means of a soil thermograph, of the sum of degrees of temperature necessary to evaporate a given quantity of paradichlorobenzene. This investigation was undertaken in view of the frequent periods of high temperatures that occur during the time the chemical is around the trees, with consequent danger of injury from the rapid volatilization of the insecticide.

SAN JOSE SCALE

Further experiments with lubricating-oil emulsion for the San Jose scale have been carried out during the year.

These tests have involved the use of Bordeaux-mixture emulsions, and emulsions of casein and various other emulsifiers, in reference to their efficiency in scale control and their safety to the trees, in connection with waters of varying degrees of alkalinity. The work at the Yakima, Wash., station indicates conclusively the necessity of using the lubricating-oil emulsion as a dormant spray at a strength of 4 per cent of oil to insure the greatest efficiency in scale control. Roughly, this dosage will destroy about 99 per cent of the insects, whereas the 3 per cent strength will leave about 3 per cent of the insects alive. An interesting question is raised as to the apparently higher resistance of the scale in the Pacific Northwest as compared to the scale in certain other fruit-growing districts of the country; for example, in the Ozarks. Further tests of the oil have been made on peaches in the Fort Valley, Ga., section, including the treatment, now repeated for the third year, of peach trees with emulsions of various strengths. From the year's work the conclusion has been reached that one application of a 3 per cent oil emulsion, or two applications of a 2 per cent oil emulsion, is necessary for best results in destroying heavy infestation by the insect on peach.

In the Bentonville, Ark., region, where a few years ago this pest occurred in very disastrous numbers, it has now been completely subjugated by means of the oil-emulsion spray. At the Vincennes, Ind., station further tests of lubricating-oil emulsion for the control of the San Jose scale on apple have been carried out, including tests of the oil emulsion with Bordeaux mixture, which appears slightly to reduce its effectiveness when used below the 2 per cent strength. This difference is not manifested when the oil is used at 2 per cent strength or above. Tests of lighter oils have indicated that those having a viscosity of less than 90 are probably slightly less effective for scale control than the heavier oils. In the dosage work applications of the emulsion up to 20 per cent have been made without injury thus far to trees treated. Additional tests of the oil on apple foliage indicate that such applications should be avoided wherever possible and given only when the trees are suffering severely from this scale owing to lack of proper winter treatment.

"Cat-face peaches."—A curious malformation of peaches appears to be increasing in importance each year in

the Vincennes, Ind., area. The injury is designated as "cat-face peaches," and some orchards have suffered at least 50 per cent injury the present year. Studies thus far indicate that the tarnished plant bug is responsible for a major part of the trouble.

APPLE INSECTS

Studies of apple insects have been carried on at several of the bureau's field laboratories. At the Bentonville, Ark., station special attention has been given to further investigations of various apple leafhoppers, of which several species occur in injurious numbers in that territory. The work has involved detailed biologic investigations of *Erythroneura obliqua*, *E. maculata*, *Typhlocyba rosae*, *Empoasca fabae*, and *E. maligna*, and spraying and dusting experiments in their control in orchards. It is expected that by the close of the present growing season this investigation will have been completed, when manuscript will be prepared giving a detailed report on the work. Little attention was given to the codling moth at the Arkansas laboratory in view of the thoroughgoing studies on this insect already accomplished in that section.

At the Yakima, Wash., laboratory further studies of the European red mite have been made, including biologic observations and control work in orchards. The life-history studies have been fairly well completed, and the experiments in orchards conclusively show the effectiveness of a 3 per cent lubricating-oil emulsion against the winter eggs and of a 0.5 per cent strength of the same spray material during the summer against the mites and summer eggs. Manuscript on these studies will be prepared and submitted for publication by the close of the present season. Apple aphids also have been studied at the Yakima station. Tests of lubricating oils as summer sprays have shown a fair degree of control, and by the addition of one-half the usual quantity of nicotine sulphate containing 40 per cent of nicotine to the emulsion its effectiveness is greatly increased. In other words, a spray containing 0.5 per cent of lubricating oil and nicotine sulphate (40 per cent nicotine) at the rate of 1 part to 2,000 parts of water is, during hot weather, entirely effective against apple aphids. At this station studies of various apple tree hoppers have been continued and this work is nearing completion. It has been found that a

dormant oil spray will kill a large percentage of the winter eggs of these insects. During July an investigation was made of an outbreak of the snowy tree cricket in southern Idaho. The insects were doing much damage, especially to prunes. The outbreak appears to have been local and has already been reported upon in an entomological journal. Certain studies of the codling moth have been continued, especially to determine the value of oil sprays as ovicides, and the effects of the various baits for the adults in the spring. It has been found that a mash of fermented apples has some attractive influence, and small jars of mash hung in trees caught on an average three moths per tree per day during the three weeks when the adults of the first generation were in orchards in numbers. Tests have been made of several brands of calcium arsenate as replacing arsenate of lead for codling-moth control on apple, results of which will be available in the fall of 1925. At the Vincennes station banding records are being taken for the codling moth to assist in advising growers as to the best times to make spray applications.

The apple leaf roller is attracting attention by its injuries in southern Indiana, and it is being investigated along with other insects of the region. In one case there was a loss from the first brood of 20 per cent of the apples by the larvæ eating into the young fruit. Injury occurs in well-sprayed orchards, indicating the difficulty of its control.

The apple flea weevil in the Vincennes area appears to be on the increase. The best method of control, namely, clean cultivation, will interfere with the straw-mulch system followed in many of the orchards in that region. Arsenicals appear to have but a slight effect upon the beetles, but it may be that they will yield to other stomach poisons, for instance, some of the fluosilicates.

GRAPE INSECTS

Investigations of grape insects, with headquarters at Sandusky, Ohio, and in cooperation with the Ohio Agricultural Experiment Station, have been continued along the lines formerly indicated. Additional work has been done in improving various methods of applying sprays to vineyards to obtain the greatest effectiveness in the control of the respective insect pests, and requiring the minimum of man power in spraying operations. Thus,

in spraying for grape leafhoppers it is necessary to reach the under surface of the older leaves, and for the grape berry moth the grape clusters should be thoroughly treated. Tests of various types of vineyard spray booms have been conducted and a nozzle arrangement developed which has proved more satisfactory than any of the appliances previously tested. A converging spray is obtained, and both sides of one or two rows are sprayed at the same time. From seven to nine nozzles under good pressure are required for each boom, the exact arrangement and number of nozzles depending upon the size of the vines and system of vineyard pruning. It has been found that with a properly designed spray boom, operated with a power sprayer of sufficient engine power and pump capacity, very satisfactory results can be obtained. The time required is much less, and the number of men required to operate a power spraying machine is reduced from three to one.

In general the usual recommendations have been to spray for grape leafhoppers when most of the eggs have hatched and when the nymphs are present on the leaves in maximum numbers. Although treatment at this time is fairly effective, results of experiments the present season, as well as results of experiments for the last three years, indicate that much more satisfactory control can be obtained by earlier spraying. This improvement depends upon the ovicidal effect of the nicotine, as it has been found that few eggs hatched from leaves well covered on the under surface with 40 per cent nicotine sulphate at the rate of 1 part to 1,200 parts of water. Excellent results in leafhopper control have been obtained the present season by using nicotine in the mixture applied for the berry moth about one week after the close of the blooming period. Experiments are under way to ascertain the efficiency of calcium-cyanide dust as a leafhopper control, the results being compared with those obtained from dust and liquid applications of nicotine.

NUT INSECTS

Investigations of nut insects were continued, as previously reported, at French Creek, W. Va., Thomasville, Ga., and Brownwood, Tex. At the first-mentioned station the biologic and other studies of the hickory spiral borer, injurious to young hickory and pecan trees by severing stems and

branches, have been brought to a point warranting the preparation of a paper for publication. Studies made during the last several years on chestnut weevils have been practically concluded and a report prepared for publication. Studies of the hickory twig girdler, except for further necessary observations on an egg parasite of considerable local importance, have been completed, and a report is in the course of preparation. An *Agrilus* beetle, the identity of which has not yet been settled positively, is seriously injurious to hazelnuts throughout the Appalachian region from Virginia northward. The larva of the beetle girdles and kills the twigs of its host plant, at least as far north as Connecticut. This insect, along with several other more or less occasional nut-attacking species, is being investigated. A publication on insect pests of nut trees throughout the Northern and Eastern States is in the course of preparation.

Investigations of pecan insects in Georgia and Texas have been continued along the same general lines as formerly. Further experience has been obtained in the use of sprays and dusts in the control of the pecan nut case bearer and pecan leaf case bearer. The results of treating pecan trees for the former insect have shown a saving of some 20 to 30 per cent of nuts as compared with untreated trees. In addition to these major pecan pests, studies have been carried on of the pecan weevil, the obscure scale, the pecan *Phylloxera*, and certain insects of minor importance, as the bud moth, curculio, catocala, twig girdler, termites, etc. The use of arsenicals on pecan has apparently resulted in an increase of an aphid, *Monellia caryella*, perhaps owing to the effect of the arsenical on the ladybird and other enemies of the aphid.

ORCHARD INSECTICIDES

Investigations of miscellaneous insecticides have been continued at the laboratories in Washington and at the near-by field stations at Sligo, Md., and at various field laboratories in connection with specific projects. The investigation of oil insecticides in progress has been continued and enlarged by the bringing together of several projects under one group leader. Closer contact with the Bureau of Chemistry has been effected in this general field, and the following co-operative projects have been undertaken:

(1) A study of the properties of emulsions of paraffin base oils made by the use of soap and other emulsifiers, especially their stability under various conditions and their use under both laboratory and field conditions.

(2) A study of the proportions and conditions for the manufacture of the best practical emulsions.

(3) An investigation of miscible oils.

(4) A study of the removal of unsaturated compounds from petroleum oils and the value of all portions of these oils as sprays for citrus insects.

Studies of dipyrityls and allied compounds, also in cooperation with the Bureau of Chemistry, have been continued, and an additional report on these studies will soon be submitted for publication. Studies of compounds related to pyrrole have also recently been undertaken in cooperation with the Bureau of Chemistry and several new compounds investigated and new compounds prepared. A very useful feature of the insecticide investigations has been the preparation of an annotated index of insecticides in use throughout the world. This work, under way for some years, has now reached a point where more or less complete bibliographies on special subjects may be quickly made up.

Further attention has been given to plants containing insecticidal properties, in cooperation with the Bureau of Plant Industry. In this connection further investigations have been made of insecticides derived from Derris, Pyrethrum, and *Hura crepitans*. In connection with studies of insect tropisms, an olfactometer has been developed which is fairly satisfactory for certain insects, and by its use practically all of the interfering factors can be controlled, so that the attractive or repellent responses of a given preparation can be measured. Incidental to studies of insecticides, evidence has been obtained to indicate that the odor responses of insects depend largely, if not totally, on the physiological state of the insect under experiment; thus in the case of the Colorado potato beetle the insects while young are concerned chiefly with feeding and invariably respond to food odors; as they grow older mating begins and the insect odor and sexual odor become predominant. Interesting and profitable results are expected from this line of inquiry.

At the Sligo, Md., laboratory further attention has been given to the development and testing of the higher fatty-acid emulsion as an aphicide, with particular reference to the control of apple aphids. In the course of the work it was found that the effectiveness of the emulsion was increased

when combined with a neutral soap which caused the spray to wet and envelop the aphids more completely. It has been found that fatty-acid emulsion is incompatible with lime-sulphur and Bordeaux mixture. It is compatible with lubricating-oil emulsion and may therefore be employed in this material in the delayed dormant application for apples in the control of the San Jose scale and apple aphids. Fatty-acid emulsion, without a soap spreader, may also be used in combination with arsenate of lead and colloidal sulphur.

WORK ON THE JAPANESE BEETLE

During the year work on the Japanese beetle has been considerably broadened, and Loren B. Smith has been placed in charge. Increased appropriations were made to meet the greater cost of operation, particularly of the farm-products and nursery-stock inspection. Investigational activities have been broadened and certain new lines of study undertaken. The work on parasites of the beetle has been materially strengthened, and men have been established in Japan, China, and India. Several phases of the investigational work have been completed.

An exhaustive study to determine the value of a large number of organic compounds as soil insecticides has been made during the last three years. The conclusions drawn from these studies indicate that carbon disulphide, used either as a gas or in the form of an emulsion, is superior, as a soil insecticide to control the Japanese beetle, to any of the other chemicals studied. Certain difficulties were encountered in preparing emulsions of carbon disulphide because of a tendency of these emulsions to stratify on standing. A new emulsion was developed, known as carbon-disulphide potassium-oleate alcohol emulsion. This material does not stratify on standing and has been used extensively and successfully by commercial concerns during the fall and spring of 1924.

Continued studies have been made of methods of treating soil about the roots of evergreens to prevent the distribution of the grubs in such soil along with these plants. In the past balled nursery stock has not been successfully fumigated in a closed container, since the aerial portions of the plants were injured by the gas. A closed container has been devised for this purpose by means of which plants

with a soil ball about the roots can be successfully fumigated. The method consists in the use of a tank filled to a certain level with water, a space being left between the water and the top of the tank sufficient to contain the soil balls of the plants being treated. The plants are inverted and the aerial portions submerged while the soil balls and roots are exposed above the water to the action of the gas. Carbon disulphide has been found the most satisfactory fumigant. This method may be practical for large-scale treatments for certain classes of nursery stock. It was found that the grubs can be killed in soil balls from 12 to 15 inches in diameter with an 8-hour to 10-hour exposure to the gas.

Investigations were completed on the dipping of plants with a soil ball about the roots in various solutions to destroy any grubs present. Even where the soil ball is exceedingly small the kill obtained by dipping is not constant, although under certain conditions 100 per cent kill could be obtained. Any method of treatment which is to be used on nursery stock must give 100 per cent control constantly. Therefore this means of treatment will not permit certificate of freedom from infestation.

The studies relating to the treatment of golf greens and lawns to destroy the larvæ have been continued, and a proportioner has been devised which eliminates the use of a large tank as a container for the dilute emulsion. The proportioner can be attached to the hydrant and connected to the distributing hose. The flow of water and the pressure are regulated by the outfit and at the same time the required quantity of concentrated carbon-disulphide emulsion is automatically added to the water stream as it passes through the machine. Several golf clubs have treated their putting greens by this method with excellent results. This device will be of inestimable value to golf clubs, since it can be used not only in Japanese-beetle-control work, but as a means of applying many insecticides and fungicides to the greens or to lawns.

Every effort has been made to obtain additional data concerning the life history of the Japanese beetle and to compare them with the results of previous studies. In the summer of 1924 the adult beetles appeared from 10 to 14 days later than in the previous season. The heavily infested territory was much larger and now includes nearly 500 square miles of territory. In late July and early August

there were several large migrations of beetles into the city of Philadelphia, and particularly into the market districts and freight yards. Thousands of beetles appeared suddenly on several occasions in the city and disappeared almost as quickly several days later. Two of the more important flights occurred on July 28 and August 10. On both of these days the beetles were abundant in Camden as well as in Philadelphia, and infested the business section of the city. It was apparent that the beetles had been flying for several miles before reaching the city. An examination showed that the females outnumbered the males on both occasions, and as many as 20 fully formed eggs were found within the bodies of the females examined.

Surveys were made in 96 localities in the heavily infested area to determine the larval abundance. It was found in the fall of 1924 that the average number of larvæ was slightly below the average of the two previous years, although certain localities showed large increases. It was also found during the winter of 1924-25, on the basis of examinations made every two weeks, that the larvæ had not gone deeper into the soil than 7 or 8 inches at any time during the season. The average depth at which they were found was 5 inches, as compared with an average of 8 inches during the previous winter.

The ecology of the insect is being carefully studied, the object being to obtain information which may throw light on the possible future distribution of the Japanese beetle in the United States, as well as information relative to its habits should it become established in other portions of the country.

Investigations have been continued on the microorganisms affecting the Japanese beetle larvæ. It has been observed that certain bacterial forms present in the bodies of dead or dying larvæ are particularly virulent when inoculated into healthy larvæ. Some of the isolated lethal forms proved to be spore formers, and the larvæ may be killed by direct inoculation or, in some cases, by feeding on decaying matter in inoculated soil. The various organisms found have proved to vary in virulence, the virulence in many cases apparently depending upon the environmental conditions at the time of inoculation. It was found that four undescribed organisms are apparently constant in their occurrence in the alimentary tract of normal

larvæ. This project is being continued in the hope of developing virulent strains which may have some practical control value.

Considerable progress has been made in the liberation and rearing of several species of parasites. The tachinid fly *Centeter cinerea*, one of the more important species occurring in Japan, has surely become established in the United States. This parasite was recovered in 1924 from releases made in 1922 and 1923 and was found to have become distributed over an area of 12 square miles in New Jersey. At the close of June, 1925, this parasite was found to occur over approximately 40 square miles in New Jersey, and during the month of June beetles bearing the eggs of this species were relatively common in the Riverton-Moores-town area. In the summer of 1924 a colony of this parasite was established near Torresdale, Pa. Parasitized beetles were later collected at this point, thereby indicating the probable establishment of this species in Pennsylvania also. The tachinid *Ochro-meigenia ormioides* was successfully shipped for the first time from Japan to New Jersey. A sufficient quantity of these parasites was received to permit of releases in the field. Large shipments were also made of a dextiid fly, *Prosenia siberita*, and colonies were released both in New Jersey and in Pennsylvania. Several species of *Tiphia* have been received, reared, and released. Much of the parasite material shipped from the Orient to New Jersey has arrived in the dormant or immature condition. Attempts will be made in 1925 to ship the live adults and in this way reduce the heavy mortality which has been occurring, as well as the large amount of expense and labor necessary when the parasites are reared after they have been received in New Jersey.

Continued progress has been made in the study of methods of control of the adult beetle. The results obtained from spraying with 3 pounds of arsenate of lead to 50 gallons of water indicate that a fairly good protection to both fruit and foliage may be obtained with this material. The kill which is obtained is not very great. In order to obtain a larger kill a preparation was devised consisting of a mixture of lead arsenate and an insoluble soap such as lead oleate. Cage experiments and field tests carried on during the past two years indicate this to be a most excellent insecticide against this insect. Another preparation was devised consisting of a

poison, such as lead arsenate, intimately mixed with a fatty acid, such as oleic acid, and this has proved effective. When this mixture is sprayed on the foliage, the oleic acid on drying forms more or less of a water-resistant film holding the particles of arsenate of lead to the foliage for considerable periods of time. Apparently it reduces the repellency of the arsenate of lead, and as a result is eaten more readily by the beetles.

For the last three years investigations have been under way to find a material which would be decidedly attractive to the beetles and which could be combined with a poison spray in such a manner that the beetles would feed readily on the sprayed foliage. From a study of the various essential oils derived from the favored fruit plants of the Japanese beetle and the several constituents of the oils, a material known as geraniol was found which is decidedly attractive to the beetles. Experiments have demonstrated that by using exceedingly dilute mixtures of geraniol and placing it in the field the beetles can be attracted in large numbers for a distance of nearly one-half mile and can be concentrated on plants in a relatively small area. There they may be killed by a contact spray, or they may be caught in traps, or killed by allowing them to feed on a poisoned bait. Traps have been devised which, when baited with geraniol, will capture as many as 3,000 beetles an hour during the time when the beetles are active. Poisoned baits consisting of some carrier, such as bran and molasses, mixed with geraniol and a suitable poison, have been successfully used. It is anticipated that this material, as its uses are developed, will prove of very great value. Extensive investigations are being carried on relative to the use of arsenical substitutes as poisons for the Japanese beetle. Studies are also being made in connection with the influence of spray deposits on the foliage and on the movements of the beetles. Further work is being carried on relative to the development of an efficient and cheap contact insecticide. There are several materials which can be successfully used to kill the beetles when used as direct or contact sprays. The purpose of the present investigations is to select and improve the most promising ones.

QUARANTINE AND INSPECTION WORK

In cooperation with the States of New Jersey, Pennsylvania, and Dela-

ware, and with the Federal Horticultural Board, the prevention of the spread of the Japanese beetle has been enforced to the fullest extent possible with the funds available. A revision of Notice of Quarantine No. 48, effective April 9, 1924, included an area of 3,289 square miles, which contained a population of approximately 2,813,658 people. During the summer of 1924 the inspection included most of the farm products found in the Philadelphia markets, as well as many articles shipped direct from the farms. The inspection also included nursery, ornamental, and greenhouse products, sand, soil, earth, peat, compost, and manure. The inspection of farm products was operative during the period from June 15 to October 15, whereas the inspection and regulation of the movement of nursery stock and products was effective throughout the year.

It was found by the close of the season of 1924 that the beetles had spread over a territory of approximately 5,122 square miles. In addition to this, three beetles were found on Montgomerys Island, near Milton, Pa., at a distance of about 100 miles from the main infested territory. Much of the spread occurred in the southern part of New Jersey, and all portions of this State south of the Raritan River, except a few townships in Monmouth County, were included in the quarantined area. The spread westward in Pennsylvania was about normal. Several beetles were found in the city of Wilmington and the townships in northern Delaware.

In the State of New Jersey 1,612,287 packages of farm products were certified during the summer of 1924. From these, 68,476 beetles were removed from sweet corn, 519 from peas and beans, 30 from tomatoes, 4 from cabbage, and 1 from cherries. In addition, 809 packages of various outdoor-grown flowers were inspected, from which 128 beetles were taken. Inspectors were maintained on call at strategic points throughout this State and inspected all quarantined products which the growers desired to ship to points outside the area. Inspectors were also placed on main roads leading out of the regulated area whose duty it was to stop all trucks passing out of the area which were hauling quarantined produce. In case it was found that such products were properly inspected and certified they were allowed to proceed, otherwise they were turned back. Twenty-eight cases of violation of the quarantine in the

State of New Jersey were turned over to the New Jersey Department of Agriculture for action. The violators were warned and signed affidavits that they would make no further violations. Approximately 86.5 per cent of all the inspected products were carried out of the area by automobile truck, only about 13.5 per cent having been shipped by rail.

In Pennsylvania the problem relates more particularly to the markets and commission houses in the city of Philadelphia, since very little grown on farms outside of the city is shipped to points beyond the quarantined area. In Philadelphia many products could be inspected and certified according to the regulations. Certain other articles were of such a nature that they could not be inspected, and in the case of these the quarantine operated as an embargo. Platforms were constructed at three points convenient to the markets and all produce consigned to points outside was hauled to them, inspected and certified, and then allowed to proceed to its destination. In all, 42,852 shipments of produce were certified from the city of Philadelphia during the summer of 1924. During periods when the migratory flights of the beetles occurred it was necessary to refuse inspection and certification of all farm produce owing to the large number of beetles flying in the market districts and freight yards. Beetles were observed flying into open cars of produce and several carloads shipped on July 23, immediately preceding a heavy flight, were followed to their destination, and one car opened at Reading, Pa., was found to contain 200 beetles which had flown into the car as it was being loaded. Several carloads of bananas loaded on the same day were followed to their destination, but no beetles were found in these cars. At the limits of the regulated area all possible roads were conspicuously posted with large signs giving information regarding the restrictions of the quarantine. Inspectors were placed on all principal roads for 24 hours a day, and the road inspection was maintained by a large force of department inspectors supplemented by 17 State police during the height of the season. An office was established in Wilmington, Del., which was charged with the responsibility for the work in that State, which consisted largely of road inspection to prevent uncertified produce from entering uninfested portions of the State. A small amount of inspection and cer-

tification of farm products was done in the township of Brandywine, in northern Delaware.

With the extension of the quarantine to include southern New Jersey the shipment of sand and soil used for molding purposes and for the manufacture of glassware became an item of considerable importance. It was found during the season of 1924 that 11,928 carloads of sand and soil were shipped from the quarantine area to 20 different States, as well as to several points in Canada. In the future much of this sand and soil will require chemical treatment before it can be shipped out of the area.

When the quarantine on nursery stock was first enforced several years ago it was realized that an embargo on the movement of nursery stock with soil about the roots out of the Japanese beetle area would work a serious hardship on nurserymen and others located in the area infested or which would soon be infested. The policy was adopted that, provided treatments were found which would *entirely free the soil from infestation*, plants with soil about the roots would be certified for shipment after having been treated. Several of the large nurseries are infested, and during the fall of 1924 it was necessary to treat large quantities of evergreen stock. As a result of the investigations which have been carried on for the last several years, it was possible to apply a method of treatment which rendered the soil absolutely free from infestation without injury to the plants. This consisted in the application of a large quantity of dilute carbon disulphide emulsion to the soil about the roots of the plants. During the fall of 1924 about 10,000 evergreen plants were treated by nurserymen under the supervision of inspectors of the United States Department of Agriculture. These plants were later certified for shipment to points outside of the infested area. In the spring of 1925 over 30,000 trees were successfully treated in this manner. Certain types of stock are either grown in such a manner that they can not be successfully treated by this method or else are so tender that they are injured by the chemical. For a few classes of such stock it has been found possible to use an emulsion of wormseed oil with effective results. A few classes of stock present a problem which as yet has not been solved, and studies are being made to solve it. The nurserymen are required to fur-

nish all the necessary materials for the treatments and enough men to assist. The actual operation of treating the plants is controlled and supervised by the inspectors. Should any conditions arise during the course of the treatments which might lead to a suspicion that any treatments might not be 100 per cent successful, certification is refused.

WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH

This work has been continued under the direction of A. F. Burgess. Field headquarters are maintained at Melrose Highlands, Mass., and the laboratory, suboffices, and storehouses have been continued as during the last fiscal year. This division cooperates harmoniously with all the infested States.

FIELD WORK IN THE BARRIER ZONE

The barrier zone, which was outlined last year, embraces a strip of territory from the Hudson River to the eastern boundary of Berkshire County, Mass., and averages about the same width north to the Canadian border and south to Long Island Sound.

The New York Department of Conservation conducts scouting and clean-up work throughout the southern part of the strip that is located in that State, while the bureau is doing similar work in the northern part of the New York area and in the balance of the zone in Vermont, Massachusetts, and Connecticut. The State of New York is also carrying on clean-up work in three small areas on Long Island, and the insect is nearly exterminated in these localities.

During the previous fiscal year the funds available were not sufficient to scout all of the territory in the barrier zone. With the additional funds made available during the present fiscal year it has been possible to scout all the towns in the zone and to determine the condition of the territory and its suitability as a barrier.

No new infestations were located in towns previously scouted except at Benson, Leicester, and Pownal, Vt., and at Stockbridge and Sheffield, Mass. These infestations were all small and should be cleaned up this year. Of the towns scouted this year where no work was attempted during the fiscal year 1924, infestations were located at Norfolk and North Canaan, Conn., and at Chesterfield and Moriah, N. Y. No infestations were found in

the towns of Fairfield, Charlotte, Salisbury, Castleton, and Bennington, Vt., Williamstown, Cheshire, Dalton, Pittsfield, and Alford, Mass., and Salisbury and Hamden, Conn., during the fiscal year 1925, although small infestations were located in all the towns mentioned during the scout of the previous year. With but few exceptions the clusters were greatly reduced in number in the towns found reinfested.

In the section of the zone which is being handled by New York State 11 infestations were found this year. Several localities found last year were cleaned up, and with the treatment applied during the spring of 1925 the number should be further reduced.

In the fall of 1924 a gipsy-moth colony was found by assistants of the entomological branch of the Dominion of Canada near Henrysburg, Quebec, about 3 miles north of the international line. It is so situated that it can be readily exterminated, and is being thoroughly treated by the Canadian department.

It now seems that the plan for maintaining the barrier zone is feasible and there is every reason to believe that it will be possible within the next two years to discontinue work in some of the towns where no infestation has been found and to move the line eastward. Prior to this, however, some scouting work should be done, particularly in the valleys extending to the westward from the Hudson River, and plans have been made by the New York Conservation Commission to start this during the coming fiscal year. Some additional work will be required on Long Island, but it will be carried on by the State force.

FIELD WORK IN NEW JERSEY

As the result of scouting work in the fall of 1924 in the worst infested part of the area in New Jersey it was found that the infestation had been reduced to such a point that it was possible to curtail the work in that area in order to release men to carry on extensive scouting operations in the territory surrounding the entire infested area. This work was begun in January and a strip of towns approximately 10 miles in width was scouted. One small colony was found in the residential section of Elizabeth, N. J. It has been treated, as well as all the infestations in the central area. This work marks the beginning of the closing-in process which will result in the gradual reduction of the territory by working from the outside

toward the center. The condition of the territory is better than ever before. In order to complete this extermination project it will be necessary to make heavy expenditures during the next two years, but after that period the cost of the work can be gradually reduced.

The weather during the spraying season was unusually favorable and a greater acreage was treated than heretofore. The effectiveness of the spray was greatly increased by the use of fish oil as a sticker.

A light truck sprayer has been devised and put into operation in the barrier-zone district during the present season. The results have been very satisfactory and indicate that the use of such a machine is feasible where small colonies have to be treated and mobile apparatus is required.

QUARANTINE AND INSPECTION

On July 1, 1924, the Federal Horticultural Board extended the area which was under quarantine for the gipsy moth so as to include the entire State of Vermont, and a few towns were added in Maine and Connecticut.

The inspection work in the quarantined area has been readjusted by combining a number of quarantine districts and by having the district foremen who take charge of sections of the barrier zone handle also the inspection and quarantine work in their districts. This has made it possible to conduct the work without increasing the permanent force.

On account of the rearrangement of the quarantined area, particularly in Vermont, and the lifting of State embargoes against the shipment of Christmas trees and greens, an enormous volume of this material was shipped during the fall of 1924. So great were the demands for inspection that it was necessary to transfer temporarily over 100 men from the scouting and extermination project to take care of this additional work. The volume of nursery products shipped during the year has been heavier than usual, the number of certificates issued on this class of products being 50 per cent greater than for the previous year. A total of 121,410 certificates and permits were issued during the year.

FIELD AND LABORATORY RESEARCH WORK

The European parasite work has been continued during the year in Spain and Portugal, and also in Hungary, Poland, and Czechoslovakia, and

much information has been gathered as a result of observations made in infested areas in surrounding countries.

Methods of shipping parasites have been greatly improved, and the material has arrived in better condition than in previous years. This has been due partly to cooperation and help obtained from the various embassies in European countries, the one at Paris having given much assistance in expediting shipments. The steamboat officials and the United States dispatch agent at New York have assisted materially in facilitating the delivery of shipments.

One lot of parasites, *Apanteles vitripennis*, was brought back from Europe to Melrose Highlands by one of the entomologists on the laboratory staff and received constant care en route. This proved to be the most feasible method of handling this particular species. In previous years most of the specimens of this species, shipped in the usual way, died en route. The biological work on a number of the new introductions has been carried on with great care; methods of handling have been improved and additional information obtained as to the best method of shipping different types of parasites.

The work of checking up field parasitism in the infested area in New England indicates that the percentage is not so great as during the previous year. Breeding and colonization work has been continued with practically all of the parasites that have already been successfully established. Most of the colonies have been placed in, or immediately adjoining, the barrier-zone area, and several colonies of *Compsilura concinnata*, a tachinid fly that attacks many native hosts as well as the gipsy moth and the brown-tail moth, have been liberated in New Jersey.

Several papers dealing with the biology and morphology of introduced parasites have been submitted for publication. The building and successful operation of a light power sprayer, mounted on a 1-ton truck, together with the development and successful use of fish oil as an adhesive, are among the most striking results secured during the year.

THE PRESENT STATUS OF THE GIPSY-MOTH PROBLEM

The results of the field work in New Jersey have been very encouraging and the condition in the barrier zone is satisfactory. The whole area has

been thoroughly scouted, the small number of colonies found have been treated, and the infestation as a whole is less than during the previous fiscal year. Cooperation by the State of New Jersey on the former project has continued during the year, and the State of New York has handled a large part of the area in the barrier zone that lies within its boundaries. All of the New England States have assisted in the zone work or on other projects.

Gipsy-moth infestation over the greater part of the infested area has not been serious enough during the year to cause much heavy defoliation. Field observations extending over the greater part of the area indicate, however, that the insect is slightly more abundant this year than during the year previous. A notable exception to the first of these statements is found on Cape Cod, where widespread defoliation took place in nearly all of the towns between the Cape Cod Canal and Orleans. Careful observations indicate that nearly 25,000 acres were completely defoliated and that nearly as large an area suffered partial defoliation. In the same towns during the previous year no large areas were defoliated, and this sudden outbreak, which occurred in spite of the fact that many species of parasites were well established in this region, is a cause of much anxiety as to what may happen later in other parts of the infested territory.

The brown-tail moth was less abundant than during the previous year, although small defoliated areas were present along the seaboard in New Hampshire and southwestern Maine.

CEREAL AND FORAGE INSECT INVESTIGATIONS

G. A. Dean was charged with the work of this section until his resignation June 1. W. R. Walton acted in charge for the rest of the fiscal year.

- EUROPEAN CORN BORER

During the year this pest has spread rapidly in the northern part of Ohio, southeastern Michigan, and northwestern Pennsylvania. The area added by this extension of territory was nearly 9,000 square miles. Of this area more than 4,000 square miles are in Ohio, but Michigan was invaded to the extent of more than 2,000 square miles. It is probable that this dispersion occurred by the flight of the moths, but whether these all originated in the United States is a question that can

not be answered at present. The infestation which has existed in southern Ontario for several years increased in intensity so greatly during the past year that the situation here is regarded as grave, and it is altogether possible that large migrations of moths from this region reached both Michigan and Ohio. The corn-borer infestation in the Ohio-Michigan area has trebled in intensity since the last account of the conditions prevailing there, although an earnest effort to clean up the infested fields was made during the spring of 1924. Since that time all of the infested States of the Lake region have enacted compulsory clean-up legislation, and the enforcement of these regulations has begun. The method of enforcement was made the subject of a conference of State and Federal regulatory officials held at Cleveland, Ohio, July 21, when uniform action was agreed upon. It is hoped that by these means the repression of the pest may be facilitated. During the summer of 1924 it was found that a slight infestation which occurred last year in Brooklyn, New York City, had extended across the Narrows into contiguous territory in Staten Island. This area was thoroughly burned over during the spring of 1925 under ideal weather conditions, and it is believed that the insect has been brought under control. The work of introducing the insect parasites of the corn borer from Europe, as mentioned in the last report, has progressed very satisfactorily during the year. New species of promising character have been secured and liberated in this country. Two of the species already liberated have been recovered from field collections this year, indicating that they have become established. One of these was found in the important Lake area bordering the Corn Belt, where the corn borer eventually must be most vigorously combated. Several additional promising species of parasitic enemies have been discovered in Europe by bureau investigators.

The States invaded by the pest have increased their appropriations for control work during the year and are giving excellent cooperation in this work. This particularly is true of Pennsylvania, Ohio, and Michigan. In the New England area the progress of the infestation apparently has been at a standstill recently, although some evidence of increasing intensity has been observed during the last few weeks. In the immediate vicinity of Boston comparatively little injury to

corn has been noted during the year, although the pest is present in some numbers.

ALFALFA WEEVIL

Good progress has been made in the experimental control of the alfalfa weevil by spraying methods, and a publication has been issued in cooperation with the University of Nevada, as Bulletin 108 of that institution. The feasibility of applying an efficient insecticide in dust form by means of airplanes is indicated by preliminary experiments conducted during the year.

The pest has continued to spread into California and was found in Plumas and Lassen counties during a recent survey. A most significant feature of this reconnaissance was the discovery of the insect in the territory lying along the North Platte River in eastern Wyoming. This marks the entry of the weevil to the great fertile basin of the Mississippi River, and its advent there may be fraught with grave results to the alfalfa-growing industry of this important region. Infestations are reported from Douglass, Careyhurst, and Orin Junction, all in Converse County; from Casper in Natrona County; from Glendo in Platt County; and from Lander in Fremont County. Glendo and Douglass are about 35 or 40 miles from the western boundary of Nebraska, and there is a railroad running directly from the infested area into the great alfalfa-growing section along the Platte River in Nebraska. Additional funds for survey work became available July 1 last, but as effective work of this kind can be done only for a period of about six weeks, lasting from the middle of May until the last of June, the work can not be resumed until May of 1926, when it is planned to conduct a more thorough campaign. Without doubt this is the most important development that has yet occurred in the alfalfa-weevil situation and emphasizes the necessity for intensive work on this problem.

GRASSHOPPERS

The grasshopper situation in central Texas, mentioned in my last report, has continued to improve, and, owing to the vigilance of the State and Federal workers, the outbreak has been almost entirely overcome.

A similar condition which threatened in Hastings and Jefferson Counties, Okla., was overcome through co-

operative action of this bureau with the officials of the State experiment station, although for a time the situation seemed desperate. Sporadic outbreaks of local interest occurred in California and Arizona, but no large regional infestation seems imminent at this time. Good progress has been made in the investigation of improved methods of attacking grasshoppers and crickets, and it is expected that a report on this phase of the work will be ready for publication some time in the coming year.

HESSIAN FLY

There are some indications in the North-Central States that a general wave of Hessian-fly infestation is starting, although conditions at the present writing are not serious and comparatively little loss from this pest was experienced during the year.

SOUTHWESTERN CORN BORER

Among the insects of potential importance which are being kept under surveillance is a boring caterpillar inhabiting the stalks of corn in western Texas, New Mexico, and Arizona. It has been called the southwestern corn borer, and is a close relative of the larger corn stalk borer of the southeastern coastal plain region of the country. Unlike that insect, however, it inhabits the table-lands of the Southwest up to elevations of more than 4,000 feet. Infestations involving as high as 100 per cent of the stalks in a given field have been observed in 1924, whereas in Presidio and Brewster Counties of Texas a loss of 50 per cent of the crop is reported for the year 1925. Similar reports have been received from New Mexico. Although the region now inhabited by this pest is not important from the standpoint of corn culture, there is a possibility that this insect may spread northward in years to come and invade territory where corn is of great importance. The insect is being watched by bureau investigators, and experimental methods of control have been initiated.

WESTERN CUTWORM

Immense flights of the moths of a cutworm belonging to the genus *Euxoa*, observed by bureau investigators in the summer of 1924 in New Mexico and through Colorado to Wyoming, indicated the probable occurrence during the present spring of a widespread outbreak of this cutworm.

This expectation was verified by the recent occurrence of severe injury from it throughout Oklahoma and Kansas, west of the ninety-seventh meridian. Many valuable data were obtained by bureau observers in this connection.

WIREWORMS

At the close of the growing year of 1924 the studies formerly conducted at Ritzville, Wash., in connection with the dry-land wireworms were completed and a summary of the biology has been published in the *Journal of Economic Entomology* for February of the current year. The laboratory formerly conducted at Ritzville has been transferred to Toppenish, Wash., so that studies may be initiated of a very injurious wireworm attacking a wide variety of crops under irrigation conditions in the Yakima Valley.

STORED-PRODUCT INSECT INVESTIGATIONS

E. A. Back has continued in charge of this section of the work of the bureau.

BEAN-WEEVIL INVESTIGATIONS

The investigation of weevils attacking beans and cowpeas has been continued during the year with still better results. The year's work has clearly proved that the danger of infestation in the field is from the adult bean weevils that are maturing in seeds held in storage and not from the planting of weevily beans or from carelessness in harvesting, as formerly thought. It has always been a habit for many farmers to hold over from one season to another stocks of beans or cowpeas which for one reason or another were not marketed in the year of harvest. In such stock weevils breed generation after generation so that by the time the new crops have matured there are present in neglected storage places myriads of adult weevils that instinctively fly to the field and infest the maturing crops by laying eggs upon the pods or seeds. Large numbers of small samples of beans have been obtained from various farms and portions of farms. Examination of these has made it possible to state where sources of infestation in storage occur. These results which have followed much tedious laboratory work have greatly impressed the California bean growers, and for the first time they have turned their attention to the treatment of

seeds in storage for the purpose of eliminating the supply of adult weevils from the fields. All facts developed in the scientific studies in the laboratory have been digested and their practical application brought to the farmer through numerous meetings and the work of local bean-weevil committees formed in cooperation with county farm advisers and State officials. Farmers through their committees have appropriated funds for the printing of posters carrying practical bean-weevil facts developed by the bureau.

The practical control work of the year has meant much in preventing losses. The growing of navy beans along the Atlantic seaboard has been discontinued in many places because of weevil destruction. The same trend from freedom from infestation to the development of heavy infestations has been repeated in the more newly developed bean-growing areas of California until in the Chino district the loss in 1922 was as high as 85 per cent for the entire community and so excessive in some sections of Merced County that bean growing has been discontinued. It has been estimated by certain bean growers that the California bean industry is suffering an annual loss of from 10 to 25 per cent of its crop. One Modesto farmer lost \$1,000, or 50 per cent of the sale price of his beans, in 1920, and \$1,000 out of \$1,235 during 1921. He gave up bean growing until 1925, when he learned that he could grow a clean crop by following the department's recommendations.

These few instances of actual depreciation of consigned crops due to weevil development indicate the seriousness of the California bean-weevil situation and explain why in such regions as Merced and Stanislaus Counties, where the bean acreage is estimated at 35,000 and 50,000, respectively, the growers are so heartily behind the department in attempting to bring about a practical cooperation among the growers for the elimination of sources of infestation. The feasibility of practical control on a large scale has already been proved by the work of the bureau's experts. If California bean growers can cooperate in the destruction of weevils in storage their losses on the bean market will be reduced to a negligible factor. Losses are being prevented. And this prevention of loss has developed from the purely scientific studies of the biology of the bean weevils.

Six papers containing new information have been prepared and submitted for publication during the year.

GRAIN FUMIGANTS

In my last report attention was called to the cooperative work between the Bureau of Chemistry and this bureau following the request made to the Secretary of Agriculture by the General Managers' Association of Chicago (representing the leading railway systems of the United States) that experiments be conducted to develop a fumigant of grain in grain cars more suitable than carbon disulphide, the use of which had been prohibited except at points in Baltimore and New Orleans. Department Bulletin 1313 has been published giving data of experiments referred to in the report for 1924. At the time of that report it was believed that the ethyl acetate-carbon tetrachloride mixture offered an excellent substitute for the well-known and efficient carbon disulphide. It was believed that the one great objection to the new fumigating mixture, namely, the residual odor left on the grain after fumigation, would be overcome by the development of a commercial grade of ethyl acetate that would be free from odor. The attention of farmers and grain dealers was called to the possibility of the new fumigant as one free from the fire and explosion hazard when properly used. The past season's experiments on a large scale have established the effectiveness of the fumigant for use in both grain cars, grain elevators, and exceedingly well-constructed farm cribs. Quite contrary to expectation, however, it has not seemed possible to obtain a commercial grade of the fumigant that will not leave an objectionable odor on the grain. The result has been that grain dealers and grain elevators have discontinued the use of the ethyl acetate-carbon tetrachloride mixture. Unless a better commercial grade can be made available or the grain trade educated up to taking grain carrying the odor of the new fumigant, more experimental work will be required.

In the year a report was published indicating that in the fumigation of tightly constructed chests and closets in domiciles where the odor is not a deciding factor the ethyl acetate-carbon tetrachloride mixture may be used in place of carbon disulphide. Two professional bulletins under the joint authorship of the Bureaus of Ento-

mology and Chemistry have been published giving the results of detailed experiments with fumigants for grain in railroad stock and dealing with the subject of absorption and retention of hydrocyanic-acid gas by fumigated food products.

GRAIN INSECTS

The studies of insects attacking grains other than the Angoumois grain moth have progressed. Technical papers containing new scientific data have been prepared on the biology of the saw-toothed grain beetle and the yellow and dark mealworms, and department bulletins containing entirely new data on the biology of the cadelle and the granary weevil are ready for publication. Studies of other pests are under way. In Georgia and throughout the South investigations have been continued of the rice weevil as a corn pest, and on St. Simons Island in Georgia observations have been conducted to determine the actual status of the broad-nosed grain weevil, which promises to become even more destructive to corn under certain conditions than is the rice weevil.

MISCELLANEOUS INVESTIGATIONS

Miscellaneous investigations have been made, but through lack of funds could not be carried far. Investigations have been made into methods for controlling the webbing clothes moth as a destructive agent attacking raw wool, mohairs, and alpacas in yarn factories, carpet establishments, and wool warehouses. Attention has been given to the moth-proofing of fabrics. Investigations have been made in fertilizer establishments, leather houses, and meat establishments with a view to the control of the destructive hide beetle, *Dermestes vulpinus*. Special interest has centered in insects destructive to upholstered furniture. Problems of insect control in flour mills, warehouses, retail and wholesale grocery establishments, fur establishments, department stores, candy factories, and a wide range of other concerns dealing with food products have received as much attention as limited time and funds permitted.

THE ANGOUMOIS GRAIN MOTH

The investigation of the Angoumois grain moth in the eastern wheat belt has been continued. The determination of the degree of infestation in the field previous to harvest and the rela-

tion, if any, of this infestation to the holding in storage of infested wheat or corn in farm bins and granaries has been of great interest. The harvest of 1924 was late, so that wheat was in the shock in western and central Maryland from July 4 to about July 20. A survey of 35 farms where shocked wheat was located near stored grain was made. With one exception shocked wheat on the farms was found infested. The average infestation of wheat in the shock was found to be 0.26 per cent, whereas the maximum infestation was 2.06 per cent. These percentages of infestation were determined by means of samples taken at the time of harvest and should not be confused with the phenomenally high percentages that ruin wheat left standing in the shock long after harvest. It is estimated that in wheat fields where the average infestation is 0.26 per cent there are about 25,000 moths per acre of shocked wheat. Since studies have determined that female moths may lay as many as 389 eggs and that the minimum time required for the development of one generation is but one month, the practical value of this investigation is obvious.

In the last report attention was called to the severe outbreak of the Angoumois grain moth in 1922, when the percentages of wheat kernels infested on certain Maryland farms ran as high as 80 to 90 per cent. Studies during the year have been made of climatic and other factors for the years 1897 to 1924 to determine whether it might be possible to deduce from them facts that may throw light on the cause of moth outbreaks. It was found that a considerable accumulation of excess temperature from June to October and early or normal harvests have characterized moth-outbreak years in the wheat regions shipping grain to the Philadelphia market. Severe winters appear to have a repressive effect upon the abundance of the insect, and no outbreaks have occurred in a year when harvest was late. It is hoped that this information will be of service in predicting moth conditions.

DRIED-FRUIT INSECTS

The investigation of insects attacking dried fruits, particularly in California, has been reestablished during the year on a much firmer basis. The limited work of the previous year was brought to a temporary end by the resignation of the only investigator

associated with the work during the fiscal year 1924. Early in the year covered by this report, two experts were assigned to these investigations. The results have been so gratifying that the Dried Fruit Association of California appropriated \$1,000 to augment the Federal appropriation. The work of the year has been directed almost entirely to investigations having for their object the discovery of facts of immediate practical value at raisin-packing establishments. The average raisin plant combines storage features with those of manufacture. The processing routine largely frees the fruit from one of its worst enemies, namely, the saw-toothed grain beetle. But where insects are abundant, packed goods are subject to reinfestation and are therefore fumigated just before shipment. This fumigation, valuable as it may be in respect to marketed raisins, has no effect in limiting infestation at the plant. The problem of the year has been to reduce existing infestations and minimize the hazards of infestation during storage.

In processing, raisins first pass through the stemming machine, where the bulk of extraneous matter is removed. The lighter waste material, known as stemmer trash, and consisting of sand, chaff, the small cap stems, and insects, is removed on the entrance side of the machine and is collected in picking boxes of about 1½ cubic feet capacity. On the average, 3 tons, or 120 picking boxes, of raw stock raisins produce about one box of stemmer trash. It was determined that over 95 per cent of the infestation by the saw-toothed grain beetle is removed from the raisins and falls into the stemmer trash, and as many as 154,000 adult beetles were not infrequently found in one box of such trash. Stemmer trash thus charged with insects has been formerly used as bedding material for stacks of boxes containing raw raisin stocks or for filling in uneven places about the plant yards, or it has been dumped near the plant. The result has been that thousands of beetles have found their way back into the stacks of raisin stocks or into containers of processed and often cartoned raisins ready for shipment. Since it has been found that adult beetles may live several years and lay many eggs and that the larval forms may mature in about two weeks during warm weather, no argument need be presented to condemn this practice. It invites more insect trouble not only at the plant

itself but in stores throughout the country where raisins are exposed for sale. To meet this situation the bureau expert devised a special fumigatorium of proper size to hold the boxes of stemmer trash likely to be obtained daily at any plant. Experiments have been conducted to determine the proper dosage and exposure for the destruction of beetles by fumigating the trash with calcium cyanide. The associated dried-fruit growers have appreciated the value of this work, and fumigatoriums have been built and are to-day in operation in the majority of raisin-packing plants.

Experiments to prevent the infestation of raisins stored in packing boxes in open sheds and yards at plants are still under way, although data already received indicate their practical value. Advantage has been taken of the fact that the beetles appear to crawl and not fly and that they have a tendency to crawl upward and to seek areas of lesser light intensity, to develop what has been termed an "arc barrier." This barrier is made from a sheet of galvanized iron 18 inches in width by rounding the upper 6 inches to form a perfect half cylinder of a 4-inch diameter. The storage shed is first completely surrounded by a 1 by 12 inch board set on edge, sunk 4 inches into the ground and secured to the supports of the shed. The galvanized barrier is then applied exteriorly to this board in such a manner that it extends 4 inches below the surface of the earth and with its overhanging half cylinder directed away from the shed. In the first experiment more than 6,000 beetles used were unable to surmount this hazard and enter the shed, but the value of the arc barrier can only be proved by experiments extending over considerable periods of time.

VACUUM TREATMENT

The use of high vacuum for insect control seems never to have been considered seriously by the commercial world. One of the most interesting phases of the work of the year has been the opportunity offered the bureau to conduct experiments to determine the effectiveness of a vacuum of 24 to 29 inches when used for control of stored-product insects.

Experiments have been conducted in a concrete chamber, 8 by 8 by 8 feet, specially constructed to withstand high pressures and intended for the treatment of certain warehoused commodities as a part of the equipment of a modern storage warehouse. Data

obtained already indicate that the usual fabric pests, such as are commonly destructive in stored household furnishings, as well as pests of stored food commodities, can be killed by the vacuum treatment.

When subjected to a vacuum of from 24.5 to 28 inches for 24 hours, larvæ of the Indian meal moth and the meal snout moth appeared shriveled and discolored, indicating death. At the end of 48 hours larvæ of the case-making and webbing clothes moths were brown and brittle, and adults of the granary weevil, the rice weevil, and *Ptinus brunneus* were dead. A vacuum of from 28 to 29 inches was found very effective in killing insects most commonly found in storage.

TROPICAL AND SUBTROPICAL FRUIT INSECT INVESTIGATIONS

Investigations of tropical and subtropical fruit insects have been carried out under the direction of A. L. Quaintance, as formerly.

FRUIT FLIES IN HAWAII

Investigations of fruit flies in Hawaii, including inspection and certification work in cooperation with the Federal Horticultural Board, have been continued largely along the lines previously reported. A total of 264,063 packages were inspected during the fiscal year, as required under Quarantine No. 13, this number being 26,443 greater than the number inspected during the fiscal year 1925. The details of the inspection work are shown below:

Inspections made-----	2, 263
Packages rejected as unfit for shipment-----	185
Shipping permits issued to transportation companies-----	1, 937
Bunches of bananas passed for shipment-----	242, 860
Crates of pineapples passed for shipment-----	15, 450
Crates of taro passed for shipment-----	3, 915
Crates of coconuts passed for shipment-----	341
Crates of ginger root passed for shipment-----	18
Crates of lily root passed for shipment-----	1, 294

Total packages inspected-- 264, 063

In addition, inspections of baggage were made as last year. The total number of pieces examined for sealing was 2,721, the greater part of which were trunks. Inspection and sealing

of baggage at Honolulu before sailing is still very popular with travelers.

Constant collections of the Mediterranean fruit fly were made throughout the year and careful records kept of the amount of infestation by the insect in different fruits and the amount of parasitism accomplished by the four fruit-fly parasites—*Opius humilis*, *Diachasma tryoni*, *D. fullawayi*, and *Tetrastichus giffardianus*. These general notes will shortly be summarized for publication. A study was undertaken of the susceptibility of cooking bananas, Guatemala type avocados, and papayas to attack by the Mediterranean fruit fly. In the case of cooking bananas, observations have been confined largely to the type known as Maïamaoli, the type principally of commercial value in Hawaii. It was found that green bananas inclosed in breeding cages with flies became infested and that the insect reproduced itself under laboratory conditions. In a total of 60 green fruits so inclosed, 6,841 egg punctures were made and 223 adult flies were reared. Eight green bunches of bananas on the trees, inclosed for two days in screen cages with from 100 to 150 adult flies, showed a total of 132 fruit-fly punctures. Punctured fruit when placed in rearing jars, however, failed to develop adults. In addition to the foregoing observations, examinations of bananas have been made in the Honolulu markets. From a total of 8,000 or 9,000 bananas so examined 29 fruit fly punctures have been found, but no adults have been reared from these fruits. It appears from the observations in 1925 that the Mediterranean fruit fly can breed in these green bananas under forced laboratory conditions and that fruits under natural field conditions are frequently punctured and eggs deposited. It is thus possible that successful breeding might occur under natural conditions, and further observations are to be made to ascertain whether such breeding can take place before any modification of the existing quarantine on these fruits is suggested.

In the case of the Guatemala avocado, only a few observations were made owing to the short bearing season and the scarcity of fruits of these winter varieties. Studies indicate that infestation of some varieties of the Guatemala type may occur under field conditions, and further observations will be made during the next winter avocado season.

FRUIT FLIES IN THE CANAL ZONE

Along with the investigation of other tropical fruit insects in the Canal Zone, special attention has been given to the fruit flies, as heretofore reported. The inspections made did not result in the finding of the Mediterranean fruit fly, although it is possible that the Mexican fruit fly has been found. Further study of this suspected material will be necessary before positive identification can be made. The survey for insect pests has been continued throughout the Canal Zone and additional data obtained. A species of *Hylesia*, which formerly was found almost wholly on mango, was found abundantly on avocado, stripping the trees of their leaves. An interesting *Ichneumon* parasite of this insect was reared.

Experiments have been made in the control of ants of the genus *Atta* by the use of calcium cyanide introduced into the nests with a dust sprayer. The treatment was found very effective as well as practical. In cooperation with the branch of forest insect investigations of this bureau, further tests of variously treated woods, as well as untreated kinds, were continued to determine their resistance to termite attack. In the matter of plant quarantines distinct progress can be reported. A new agricultural law passed by the National Assembly of the Republic of Panama contains provisions for plant quarantines, and their urgent need is fully realized.

GREENHOUSE INSECTS

Owing to the increasing importance of the bulb industry in the United States, special attention during the year has been given to investigations of the two bulb flies. Bulb material infested with larvæ of the narcissus fly or larger bulb fly was obtained and observations made upon them in the laboratory in Washington. It was ascertained that the larvæ pupate at or near the surface of the ground above the decayed bulb in which they fed, and the puparium is usually found in a slanting position partially submerged in the burrow. The pupal stage appears to require three weeks or longer. The adult flies emerged in the spring, during late April and May. It is believed that mating takes place only in the sunlight. Their small, elliptical white eggs are deposited on or near the bulbs; these hatch in three or four days. In the

case of the lesser bulb fly adults were reared from infested bulbs received from California and then fed in cages. The flies fed readily on honey. They deposited their small, white eggs in masses on the dry, brown skin at the neck of sound bulbs. None was found in or on decaying bulbs. Some larvæ that hatched August 26 pupated a month later, emerged in October, and laid eggs, whereas others of the same brood did not emerge until January. In order to study the bulb flies to best advantage the laboratory at Willow Grove, Pa., where work in cooperation with the Pennsylvania State Department of Agriculture has been in progress, was transferred to Santa Cruz, Calif., where the insects are prevalent. Careful investigation of these insects for a year or two will, it is hoped, throw light on practical methods of control.

Some time has been devoted to biologic studies on the development of the greenhouse mealybug, *Pseudococcus citri*. Observations especially were made on the incubation period and on the nymphal and adult development under varying conditions of temperature and humidity. The duration of the egg stage may prove to be of great importance in determining the intervals at which fumigation would be most effective. Temperature and humidity readings were recorded in connection with these studies and will be correlated with variations in the life cycle. At the Willow Grove, Pa., station studies and observations on the cyclamen mite have been continued and new facts accumulated. The adult females and eggs of this pest were found to be able to survive the low temperatures of the past winter on perennial larkspur, *Delphinium belladonna*, and snapdragon, *Antirrhinum* sp. A 1 per cent lubricating-oil emulsion has shown favorable results against the mites, although repeated applications appear unfavorable to the cyclamens as reducing the number of leaf buds. Experiments with various soap solutions as sprays for this mite are now under way. A planting of 40,000 narcissus bulbs and 5,000 tulips was recently found to be infested with this mite, constituting an additional host record for this pest. Studies on the seasonal development and number of generations of the Cattleya fly have been completed during the year. Of the various materials tested for the control of this insect nicotine dust containing 2 per cent of free nicotine was found to give satisfactory control. Additional work in the field of

fumigation has been accomplished. The effects of vacuum fumigation with hydrocyanic-acid gas in varying dosages on the vegetative and flowering qualities of amaryllis bulbs have been studied, and the indications are, from the blooming records of the plants, that the treatment with this gas does not affect the flowering qualities of the bulbs; in fact, the treated lots were in all respects better than the control plants. Considerable time during the year has been devoted to experiments with calcium cyanide to determine its value as a greenhouse fumigant. Numerous box and greenhouse tests were conducted in Washington to determine the range of safe dosages, and with this as a basis tests have been carried out under commercial conditions here and in the vicinity of Philadelphia. Results indicate that a one-fourth-ounce dosage is safe for use on rose, carnation, and several other crops. Experiments with nicotine fumigation have also been made to determine what concentration is necessary for the control of such aphids as *Myzaphis* sp. on rose and *Myzus persicae* on snapdragon. It appears that from 35 to 93 per cent higher mortalities of these insects can be obtained by using three times the recommended dosage. Nicotine dusts containing 2 per cent of nicotine were found decidedly effective in killing adult moths of *Rhyacionia frustrana bushnelli*. An unusual injury to a rose establishment by the Surinam cockroach, *Pycnoscelus surinamensis*, was reported. Work in the important field of greenhouse insects has been actively prosecuted during the year and results of much importance obtained.

CITRUS THRIPS

Investigations of the citrus thrips in California at the bureau's laboratory at Lindsay have been continued in cooperation with the Tulare County Citrus Growers' Exchange. Efforts have been directed to finding a simpler and more economical control for this insect than is now available. The varying severity of infestation by the insect from season to season interferes materially with the carrying out of a prearranged program of experiments. However, it has been possible to test every promising phase of spraying, such as winter applications, spring applications, as well as applications during both winter and spring. Some 125 acres of citrus groves were sprayed under the im-

mediate supervision of the laboratory, and results of this work will be ascertained at the proper time of harvesting of the fruit. The biologic studies of the citrus thrips are fairly well completed, though additional facts of importance have been added to information previously obtained.

FLORIDA CITRUS INSECTS

The work at the station at Orlando, Fla., has been somewhat enlarged by the transfer to it of the investigational work under way for some years at Miami, Fla., on insects attacking the mango, guava, avocado, etc. The work has been divided into two principal sections, namely, biological work and investigational work connected with control operations, including liquid and dust insecticides and the like. In the biologic field special attention has been given to the citrus aphid. Life-history studies of the insect have been made and information obtained on the duration of the various stages. The aphid has been found on many food plants, especially during the spring. An important hymenopterous parasite of the citrus aphid was unfortunately unable to maintain itself during the summer, partly on account of secondary parasites, but largely owing to the dwindling of the aphid population as soon as the citrus growth hardened. Many aphid colonies were wiped out by entomogenous fungi. Special inquiry relative to the predacious enemies of the aphid has been conducted in the laboratory to ascertain their rate of feeding, their life histories, and other facts possibly facilitating their usefulness. The studies have included four species of syrphid flies, two species of lacewings, nine species of coccinellid beetles, and a small agromyzid fly, *Leucopis americana*. Colored illustrations of all of these insects are being prepared for permanent record. In the insecticide field, investigations have been confined principally to experiments with sulphur and with various oils. The tests with sulphur have been designed to determine what form of sulphur will remain fatal to rust mites for the longest period of time and the factors which add or detract from this period of efficiency. This has included tests of various grades and brands of sulphur in determining the effects of sun, rain, humidity, and temperature on decrease of sulphur on the foliage. In the oil studies a number of oil emulsions have been prepared with various emulsifiers and it

has been found that the physical properties of oils vary with these, especially in viscosity and the size of the oil globules. In emulsions prepared with an excess of lime caseinate or kaolin there appears to be a slight reduction in efficiency of the oil against the purple scale and the Florida red scale. Further study will be necessary to ascertain the causes involved in this reduced efficiency. Oil shadowing on the fruit, it has been found, may be reduced by the employment of from 2 to 4 pounds of calcium caseinate to 100 gallons of diluted spray. Oils of the saturated and unsaturated series are being studied to determine if there is any correlation between the unsaturated compounds of oils and the toxicity of the oils to the foliage and insects. Highly refined oils and sulphonated oils have been used, and it appears that pure oils can be applied to foliage in greater concentration without injury than the dark lubricating oils. The centrifugal method of determining the percentage of oil in dilute and concentrated solutions as worked out by the Bureau of Chemistry is accurate for soap oil emulsion, but not so accurate in some of the emulsions prepared with other emulsifiers. With emulsions prepared with such materials as kaolin it will be necessary to work out a new procedure. Studies of the insecticidal value of coconut fatty acid for the citrus aphid were made during the year. Concentrations of 1 part fatty acid to 200 parts of water or less produced injury to the young growth of trees. Satisfactory aphid kill without tree injury was obtained with concentrations of 1 part fatty acid to 600 parts of water. Extracts of Derris root in sulphonated castor oil have shown great promise against the citrus aphid. This material has already been tried by several growers with satisfactory results.

VEGETABLE AND TRUCK-CROP INSECT INVESTIGATIONS

Work on the project of vegetable and truck-crop insects has been continued under the direction of J. E. Graf.

MEXICAN BEAN BEETLE

During the late summer of 1924 the Mexican bean beetle continued to spread rapidly in a northerly direction, reaching the shores of Lake Erie in the vicinity of Cleveland and extending its range along the lake al-

most to the Pennsylvania boundary. In addition there was considerable spread in northwestern Ohio. It appeared also in the counties in Indiana bordering on the Ohio River in the southeastern section of the State. The spread in West Virginia continued until the western half of the State was generally infested. The infested area increased slightly to the east and to the west. In North Carolina and South Carolina the beetle has now passed entirely beyond the main range of the Alleghenies and has invaded the coastal plain. In Virginia it has not yet succeeded in establishing itself east of the main range of the Alleghenies.

In the latter part of the summer of 1924 and the early summer of 1925 an unusually large number of reports of injury were received from correspondents. It appears that the injury has been heaviest in the Allegheny Plateau region which takes in eastern Tennessee, eastern Kentucky, West Virginia, and western Virginia and North Carolina. In southern Ohio the infestation increased rapidly during the summer of 1924 and the beetle caused heavy damage to beans that fall. The damage over the territory southeast of a line from Cincinnati to Ashtabula County was heavier than over the section northwest of that line. Near the southern end of the infested territory at Birmingham, Ala., and Newport, Tenn., the insect increased during the summer of 1924 and became very abundant in late June and July. It now seems that it is a more dangerous pest in the hilly and mountainous regions than in the plains regions.

Only minor changes in the insect's habits and life history have been noted. In the years 1922, 1923, and 1924 it appeared from hibernation later each year than in the preceding year, but in 1925 it changed its habits radically, appearing two and one-half weeks earlier than in 1924. This sudden change in habit may have been due to the hot, dry weather of the spring of 1925. In 1924 a maximum of three generations was produced, computing from the first eggs of the first beetles appearing, but in 1925 indications are that a maximum of four generations will be produced.

In 1924 the beetles were found in the woods preparing for hibernation as early as September 5, but later scouting showed that the number of beetles hibernating in woodlands was much lower than usual, only about one-tenth as many having been found.

to each unit area as in the previous year. The survival in hibernation, however, was much higher than usual, 24 per cent of the beetles in a large hibernation cage having passed the winter successfully.

Results in control studies have corresponded very closely with those of previous seasons. Lead arsenate, zinc arsenite, and the lead arsenate-lead oleate mixture were all injurious to the bean foliage under southeastern conditions. One sample of magnesium arsenate proved to be too injurious to bean foliage to be of value, but the magnesium arsenate commonly found on the market, while poisonous to the insect, proved to be largely noninjurious to foliage. The calcium arsenate and lime mixture also proved its value as in the preceding years, although in some tests it has shown itself slightly more toxic to bean plants than the magnesium arsenate. A series of tests with the fluorides and fluosilicates indicated that some of these mixtures are promising insecticides, especially the sodium fluosilicate, which was recommended by Marcovitch, of Tennessee. It was found, however, in the preliminary experiments, that sodium fluosilicate was not so uniformly effective at high dilutions as magnesium arsenate or calcium arsenate. Experiments with these materials are being continued.

Laboratory tests of the chemotropic responses of the Mexican bean beetle have been completed with 96 aromatic chemicals. With the exception of three, all were found to be repellent to the bean beetle, and these three may possibly show some attraction.

Collections were continued during the year to determine whether the Mexican parasite introduced in 1922 and 1923 had become established. None have been recovered, and it is quite probable that this parasite was never successfully colonized. In 1924 only two specimens of the native parasite *Phorocera claripennis* were recovered, and in June, 1925, several larvæ bearing eggs of this parasite were collected. To date this fly has not shown any promise of controlling the bean beetle under field conditions.

During the present spring a substation of the Birmingham laboratory was established at Geneva, N. Y., where investigations on the Mexican bean beetle and other bean insects are being conducted in cooperation with the State experiment station.

Investigations in the West have been continued mainly along biological lines, since the extremely dry weather

of the last three years has curtailed bean culture there. Experiments to determine the factors affecting the insects in hibernation have shown that precipitation is important when the insect is about to emerge in the spring. It came out in greater numbers after even moderate rains. These experiments were checked by artificially watering hibernation cages in which large numbers of beetles were wintered. Flight tests conducted with marked beetles showed that the insects fly either up or down the canyons with the prevailing winds and that they use the canyons as migration paths, both in entering and in emerging from hibernation.

Experiments with arsenicals under western conditions have shown definitely that practically none of these materials is injurious to beans under arid conditions and at altitudes of from 6,000 to 7,000 feet.

PEA APHIS

Control studies on the pea aphid have been continued, both in Wisconsin and in California, in cooperation with the State entomologists and the canners' organizations. Results during the year were not conclusive in any of the districts, owing to the peculiar nature of the infestation. Under California conditions the use of nicotine dust, applied with a self-mixing duster, gave satisfactory control of the pea aphid, the highest killing being obtained with the 4 per cent nicotine dust applied at the rate of 50 pounds to the acre. Under Wisconsin conditions the highest killing obtained with nicotine dust was about 70 per cent, whereas the aphidozer collected an average of 82 per cent of the aphids from all of the field swept. Experiments with the aphidozer are being continued in the hope of improving it so that it may be used effectively under all field conditions, and especially where the plants are unusually large.

SWEET-POTATO WEEVIL

The sweet-potato weevil eradication campaign has shown consistent progress in Florida and Mississippi. In the former State, where the work is conducted in cooperation with the Florida State Plant Board, no infestation of the weevil has been found in the original test area in Baker and Charlton Counties. In the Lilly project in southern Florida no weevil was found during the inspections in Au-

gust, 1924, and January, 1925. In Mississippi only 15 farms have been found infested during the present year in Pearl River and Hancock Counties. The work in Mississippi has been changed to some extent in order that more attention may be given to the infested districts. The workers of the Bureau of Entomology were concentrated in the counties of Pearl River and Hancock, and the project in Jackson and Harrison Counties was taken over by the workers of the Mississippi State Plant Board. By dividing the territory in this way, it has been possible to visit the infested properties with greater regularity, and this fact was doubtless responsible for much of the progress made in the eradication campaign within this State.

In Alabama the situation has become serious, owing to the finding of several infested properties and some infested morning-glory in Baldwin County, one of the heavy sweet-potato producing sections of the State. Scouting, in cooperation with the Alabama State Department of Agriculture, has been begun on a larger scale.

The attempted eradication of this insect in all of these areas is a novel experiment. To exterminate a well-established insect without seriously interfering with the production of the crop on which it feeds is something new. These methods are possible owing to the slow dissemination of the insect. The methods are all cultural in nature and include field cleaning, careful storage of the crop, and the utilization of weevil-free planting stock. When these steps are followed carefully, there results a period of several weeks in early spring when any weevils which may have survived in the old field are without food. Experiments have shown that the sweet-potato weevil can live only for a few weeks without food during the spring, and since the adult is sluggish it does not normally go far in search of food. In cases where the new planting is made at some distance from the previous year's planting and all volunteer plants in the old field are kept down, the weevil is either greatly reduced or eradicated.

SUGAR-BEET LEAFHOPPER

During the year studies on the sugar-beet leafhopper were initiated in the intermountain region, with headquarters at Toppenish, Wash. During the preceding year the sugar-beet leafhopper had been unusually abundant throughout this area, and in

most of the large districts losses from curly-top, a disease carried by the leafhopper, were so severe that the tonnage was very materially reduced and in the Yakima Valley the culture of sugar beets was practically stopped. Investigations to date have consisted principally of biological and ecological studies of the leafhopper and of the factors responsible for the abundance and migration of this pest. Cooperative studies with the Utah and Idaho experiment stations have been begun, and the insect is being studied in the desert breeding grounds. During the present spring in the intermountain region practically no loss from the sugar-beet leafhopper has been noted, owing possibly to the rainy season and the fact that the desert breeding grounds of the insect have not dried up as early as usual.

POTATO AND TOMATO INSECTS

Potato leafhopper.—Experiments for the control of the potato leafhopper have been continued in cooperation with the Wisconsin Agricultural Experiment Station. These tests are now in their fifth consecutive year and will be continued for about two years more until the results under various seasonal conditions will be available and may permit definite recommendations. The indications at the present time are that when the infestation of leafhoppers is heavy, Bordeaux mixture spray, properly applied, is somewhat more effective than Bordeaux dust.

Australian tomato weevil.—Biological and control studies of this insect, which has now been definitely determined as *Listroderes obliquus*, have been continued. As yet no males have been discovered, reproduction occurring parthenogenetically. Only one generation of this weevil is produced a year, egg laying starting during the last days of September and continuing for several months. The earliest weevils appear in December, but none of these have been found to lay eggs until the following fall. During the year the insect has been found to exist over a wide territory, including 19 counties in southern Mississippi, 17 counties in southern Alabama, 2 counties in western Florida, and 8 parishes in southeastern Louisiana. Very little work has been done on the control of this insect, owing to its scarcity. Its numbers were greatly reduced by the cold weather of the two preceding winters.

During the spring of 1925 a closely related insect, *Listroderes apicalis*,

was found in several parishes in south-eastern Louisiana. No information is available on the possible economic importance of the insect, but it is regarded with apprehension, since it is closely related to the Australian tomato weevil. Both sexes of the latter insect have been found.

Tomato suckfly.—The tomato suckfly was found during the year for the first time in the State of Mississippi. It is impossible to state just how serious this pest may become in its new environment, but it caused considerable injury in the small infested area under observation. This insect has been known as a serious pest of tomatoes in Texas for several years.

Seed-corn maggot of potatoes.—The seed-corn maggot as a potato pest was studied on a larger scale in North Carolina during the present season. Studies on the biology and habits of this insect show that the character of the soil does not largely determine infestation by the maggot, but that the insect is attracted by organic fertilizers, especially fish scrap, dried blood, etc. Where the weather is cool and dry during the early spring and the germination of seed potatoes is retarded, these insects may become serious pests, destroying a considerable portion of the seed before it has had a chance to germinate.

Tomato fruitworm.—Experiments on the control of the tomato fruitworm were conducted at Birmingham, Ala., and Baton Rouge, La. Experiments with arsenicals have given rather inconclusive results, except in a few instances. It is possible that arsenical treatment at a certain time either in the development of the insect or the crop will prove a successful remedy, but from the present information it is impossible to recommend a particular time. In some plats which received two applications when the largest fruits were about half grown and when the oldest fruits were nearing maturity, the infestation was reduced about 50 per cent. Experiments conducted in New Orleans indicated that sweet corn is worthless as a protective trap crop for tomatoes.

ONION INSECTS

Onion maggot.—Tests with the cull-onion method for trapping the onion maggot have been continued. Preliminary results indicate that the adult flies are strongly attracted to the early planted culls and deposit a large proportion of their first-generation eggs on them. In one experiment

246,000 insects were trapped on a row of cull onions one-fourth of a mile in length. Experiments in killing the various stages of the insect in the cull bulbs have shown that from 80 to 90 per cent of them may be killed by treating the cull row with cheap oils, such as road oil or crank-case drainings. Preliminary experiments planned to determine optimum arrangement of plantings of culls to obtain the maximum of protection will be completed later in the year.

WIREWORM INVESTIGATIONS

Studies on the biology and control of the western cultivated-land wireworms are being continued in Washington State and California. Indications are that the wireworms winter at an average depth of about 10 inches, and although the ground froze to greater depths than usual these worms, as well as the adults, in winter cells from 5 to 8 inches below the surface appeared to be uninjured by the cold. The wireworms work toward the surface and begin feeding early in March, thus becoming active early enough to injure seeds and seedling stocks. The first adults appeared early in April and the first egg laying was noted May 7, young wireworms appearing late in the same month. Experiments with soil fumigants have shown that the wireworms can be killed with either calcium cyanide or carbon-disulphide emulsion, but that the gases do not diffuse far in killing concentrations. Promising preliminary results have been gained by using baits to concentrate the wireworms and then following this by treating the concentration rows with soil fumigants. Injury to growing crops resulted from many of these treatments, but this may be overcome by treating the soil a short time in advance of planting. Complete meteorological records are being maintained as a check on all biological records.

PHYSIOLOGICAL INVESTIGATIONS

During the year studies have been conducted for the determination of the respiratory metabolism that takes place during embryonic development, histolysis, and pupal development of insects. The results of this study, which are considered significant and of fundamental importance in insect transformation, were published recently. The investigations have been broadened to include a study of the

toxicity of arsenicals and their effect on respiratory metabolism in the hope that a convenient laboratory method may be discovered for the determination of the toxicity of arsenicals on different insect species and thus make it unnecessary to conduct large-scale field tests for the preliminary toxicity and control investigations.

MISCELLANEOUS INSECTS INJURING VEGETABLES

Twelve-spotted cucumber beetle.—Biological and control studies on this insect are being conducted in Louisiana. Useful observations have been made on plants attractive for oviposition, but it has not yet been determined what becomes of the first-generation beetles under field conditions shortly after they appear. They have been noticed to feed for a short period, but soon leave the fields. In the laboratory two generations of the insect have been reared. Control tests on a small scale have indicated that undiluted sodium fluosilicate dusted on the beetles kills a very large proportion of them. Less satisfactory control results where the beetles are placed on dusted plants. Dilution of the sodium fluosilicate with lime materially reduces its effectiveness.

Blister beetle (*Epicauta lemniscata*).—Outbreaks of this insect were treated with various baits and insecticides. Used alone, the arsenicals were of little value, but when calcium arsenate was mixed in equal proportions with sodium fluosilicate good control resulted. Sodium fluosilicate used alone was also effective, but the use of both this material and the calcium arsenate-sodium fluosilicate mixture resulted in some plant injury.

Mole crickets.—Studies on the Porto Rican mole cricket in the Southeastern States have been broadened to include its control on golf courses and lawns. Applications of the baits which proved so successful against this insect under cultivated field conditions have again demonstrated their usefulness, especially against the young. Soil fumigants have given good control of adults, but the dosage has not been worked out to a point where they are absolutely safe to use in grass plots.

Pepper weevil.—Biological and control studies are being continued on this insect in southern California, where several extensive infestations were recently discovered. Injury in the infested fields has again varied between 10 and 100 per cent of the

crop. Cultural control consisting of clean culture immediately after harvest followed by early plowing has given the best results.

SOUTHERN FIELD-CROP INSECT INVESTIGATIONS

W. D. Hunter has continued in charge of these investigations.

COTTON BOLL WEEVIL

The use of calcium arsenate dust for boll-weevil control has continued to become established more widely as a standard farm operation, particularly in those sections of the South suffering the greatest weevil damage. For the last several years the bureau has made steady progress in improving the methods of utilizing this poison; both the poison and the machinery have undergone changes and improvements in quality as well as reductions in price, and the spread into new territory has of course necessitated many modifications in the methods of application.

The cotton season of 1924 was peculiar in that a very light emergence of weevils in the spring was followed by a phenomenal drought which to a very considerable extent controlled the weevils over a large portion of the Cotton Belt. For this reason it was not possible to conduct plat tests, as has been done in past years, particularly at the Tullulah, La., station; however, this did afford an opportunity of checking many of these experimental methods under conditions of light weevil infestation, and the heavier infestation at the station at Florence, S. C., afforded a valuable contrast.

Extensive studies, both chemical and entomological, were continued concerning the suitability of different types of calcium arsenate. In the same series approximately 300 new suggested remedies for the boll weevil were tested, much of this work having been done in cooperation with the Federal Insecticide and Fungicide Board, and where there was evidence of deliberate attempt at fraud the board was assisted in the preparation of evidence for use in prosecution.

Very important progress has been made in the use of airplanes for distributing poison. The experimental work of the past was carried to the point where commercial organizations have now undertaken this operation on a commercial scale. Of course much research work has been neces-

sary to obtain the information desired as a basis for such a commercial operation, and although there is still much to be learned, commercial activities have progressed to a point where it is shown quite definitely that airplane poisoning will be a success not only in the control of cotton insects but also for use against many other pests. During the cotton-growing season of 1925 something over 50,000 acres of cotton were poisoned commercially with airplanes, and it is evident that this area will be greatly increased within the next few years. Great progress has been made in the development of special planes for cotton dusting and in the testing of these planes, looking toward their still further improvement in the future. Studies have been conducted on the best methods of flying, the different dusting problems encountered, and on the selection of the most suitable dust for these various conditions.

In connection with these airplane studies additional observations have been carried on for the purpose of applying the principles of airplane dusting to the operation of ordinary ground machinery. Several new types of dusting machines are in course of development, and some of these have been carried to the point where they will very soon be ready for commercial production. These machines are designed particularly for operation under conditions where the older types could not be used, and especially good results have been obtained from daylight operations with them as contrasted with those obtained with the older types. The studies on the electrical charging of dust particles have been continued in the same series in cooperation with the Bureau of Standards.

Very important progress is being made on the chemical attraction of the boll weevil. The investigations of the Bureau of Chemistry on the chemical constituents of the cotton plant are now completed and two promising chemicals have been located, both in the plant and in the emanations from the plant, thus indicating that they stand the greatest chance of furnishing the odor which attracts the boll weevil to the cotton plant alone. Apparently tests of these chemicals show that they are attractive to the boll weevil, and these investigations are being continued for the purpose of determining whether or not this attraction can be increased to the point of commercial benefit.

Special attention has been devoted to the hibernation of the boll weevil. During the last 10 years the Tallulah laboratory has been making an intensive study of hibernation observations for the purpose of determining the possibility of predicting weevil abundance some time in advance. In 1924 it was decided to attempt to apply on a very extensive scale the principles learned in this study, and a cooperative series of tests was started, under which about 10 of the different State experiment stations reported to the Tallulah laboratory observations on weevil hibernation at biweekly intervals. These were immediately summarized, interpreted, and issued for the benefit of the farmers. This preliminary test was so successful that arrangements have been perfected for a much more extensive series during the coming season.

The cooperative station at Florence, S. C., has been continued along the lines originally planned. Various control measures have been given a rather thorough test under the conditions of the Southeastern States and a progress report on the results of these has been issued as Bulletin 223 of the South Carolina Experiment Station. At present particular attention is being devoted to the biological phenomena under these new conditions with the idea of determining exactly wherein the behavior of the weevil differs from that at points studied in the past, so that this information may be utilized in outlining suitable control measures.

OTHER COTTON INSECTS

The interrelationship between boll-weevil control and plant-louse damage to the cotton crop has been given more intensive investigation than ever. Methods of control, both direct and indirect, have been carried to a fairly satisfactory point, although much improvement is still expected.

The increased interest in the Arizona wild-cotton weevil brought about by its appearance on cultivated cotton at Tucson, Ariz., has made it necessary to open a permanent station in Tucson for the purpose of studying this insect with particular reference to its possibilities of damage to the western cotton crop and the means of preventing such injury.

The cotton "hopper" or "flea" has apparently been increasing somewhat in the spread of its activities, and intensive studies on its control are being

carried out along the Gulf coast of Texas. In addition, observations are being conducted in all cotton States to determine the exact extent and severity of its injury. Strong indications were found that this insect transmits a disorder of the cotton plant. The plants shed practically all of their fruit and grow abnormally tall. Such damage has occurred for a number of years in southern Texas, but in 1923 it occurred in northern Texas and in several of the eastern States in the Cotton Belt. Grave fears arose among the planters that the pest would be as important as the boll weevil. The studies included the relations between outbreaks and climatic conditions and experiments in control. It was found that flowers of sulphur is a much more effective agent in killing the insect than any of the other numerous materials tested. The indications are that methods of using sulphur on an economic and satisfactory basis may be devised.

The cotton leafworm has been increasingly active for the past several years, and a series of studies has been started for the purpose of working out improved means of predicting outbreaks of this pest, as well as the best methods of handling such outbreaks.

TOBACCO INSECTS

The green June beetle continues to be a pest in the plant beds that are used for more than one season. The remedy worked out last season has given satisfactory control and the recommendations for its use will shortly be published.

In the Burley tobacco region about Lexington, Ky., wireworms caused damage to the tobacco running into the hundreds of thousands of dollars. Losses of 10 per cent are not uncommon. An average reduction of the beetles, amounting to 71.8 per cent, was obtained in 1925 by the use of sodium fluosilicate as a bait poison at a cost of about 1 per cent of the value of the crop. This is a decided gain over the control of 55 per cent obtained with Paris green in 1924 and 1925. One application of the bait has increased the crop stand from 2 per cent in a light infestation to as much as 12 per cent in heavy infestations. It has also greatly reduced the main damage to the crop which is due to the stunting of the plants attacked.

In the dark-tobacco belt of Virginia the tobacco Crambus is a pest of major importance. In years of severity the loss amounts to from 15 to 20

per cent of the crop, totaling more than \$1,000,000; in years of comparatively light infestation it amounts to about 5 per cent of the crop, totaling about \$375,000. This loss is brought about by infestation of early settings, necessitating several replantings, the first of which may be an almost complete resetting, and the result is a reduction in yield and quality. At the Virginia Tobacco Experiment Stations at Chatham and Appomattox the annual loss has been estimated at about 14 per cent. Experiments at Appomattox in the spring of 1925 resulted in a reduction of 55 per cent of the infestation by one application of a trap bait which was applied at a cost of about 1 per cent of the value of the crop. This problem is of major importance and demands further experimentation.

The control measures for the tobacco budworm on cigarette types of tobacco, which were perfected in 1924, were brought into general use in the spring of 1925 through circulars addressed to growers, through newspaper articles, and through the cooperation of the county agents in the districts where this type of tobacco is grown. The result was a saving of many thousands of dollars to the growers.

SUGARCANE AND RICE INSECTS

The year has seen an awakening among the Louisiana sugar planters in matters pertaining to agriculture and insect control. The attention of the planters was called by the bureau to the value to the soil and to the control of the sugarcane moth borer in not burning the "trash" or cane leaves left after cutting the cane. Plowing this material under in a certain manner was recommended. This practice is at last being rather widely adopted, though the recommendation was first made a number of years ago. It was also pointed out that the borer multiplies rapidly in cornstalks, and the curtailment of corn planting or the isolation of cornfields from sugarcane fields was advised. Although it is unlikely that corn planting has been curtailed, several planters have made an effort to plant the corn in blocks separated as much as possible from the fields of sugarcane.

It was found that soaking the seed cane before planting in water of ordinary temperatures for 72 hours destroys all borers in the cane. This is very important, as it is evident that the planted seed cane provides the principal place of hibernation for the

borer, the moths emerging through the soil in the spring. One planter tried this on a small scale, and then treated practically all his seed cane. Barges were filled with cane and then pumped full of water. The germination of the cane was stimulated, and as less cane was used for planting, because no allowance had to be made for borer injury after planting, the owner of the plantation estimated that the treatment cost nothing at all. A degree of control was also obtained against the sugarcane mealybug by the use of the water treatment.

This bureau again cooperated with the Bureau of Agricultural Economics in estimating the loss in Louisiana due to the ravages of the moth borer in sugarcane. Our estimate in 1924 was that the borer had destroyed 13 per cent of the crop, or caused a loss of about \$3,500,000. In 1923 the loss was estimated at 23 per cent. In these estimates no account is taken of the damage suffered by corn.

Cooperation was arranged with the newly formed Tropical Plant Research Foundation, which has a number of specialists studying sugarcane problems in Cuba.

Studies were begun on sugarcane insects of minor importance, with special reference to the transmission of mosaic disease.

It was found that the Cuban tachinid parasite, introduced from Cuba in 1919 and 1920, is still in existence in Louisiana, though very rare. It is possible that in the course of time this parasite may become an efficient factor in the control of the sugarcane moth borer.

Experiments in controlling the sugarcane mealybug in the sirup-producing section around Cairo, Ga., were continued. Some success was obtained.

A comprehensive manuscript on rice insects and their control, not only in Louisiana but also in Arkansas and California, is almost ready for publication.

Soybeans are being adopted as a rotation crop on rice plantations, where fields not planted in rice have been allowed to grow up in grass and weeds instead of being planted in some other crop; so attention has been paid to the principal pest of soybeans—one of the blister beetles. A perfect control measure has been found in dusting the plants with sodium fluosilicate. This poison is cheap, and it is necessary to dust only the part of a field where the beetles actually occur. Dead beetles have

been found over 100 feet from the place where the poison has been applied.

INVESTIGATIONS OF INSECTS AFFECTING THE HEALTH OF MAN AND ANIMALS

The investigations relating to the screw-worm problem in the Southwest were continued throughout the year. The work looking toward the development of repellents for the protection of wounds from infestation, which is being carried out in cooperation with the Bureau of Chemistry and the Texas Experiment Station, received major consideration. Many of the materials found by jar tests to be effective in repelling the screw worm and other flies were tested on living animals which were infested with screw worms. Much valuable information on the reaction of the screw worm fly and the treated wounds to various materials was obtained. This work is of a complicated nature, requiring numerous repetitions, and hence is still incomplete, although some of the more promising repellents are being recommended to the stockmen.

Experiments were being continued with sprays designed to kill and repel the horn fly, stable fly, and house fly on cattle. Special attention was given to various Pyrethrum extracts which are promising as fly destroyers. Tests were also begun to determine the proper bases for sprays for use on livestock. This work is being done in cooperation with the Bureau of Chemistry.

Large sums are being spent in the aggregate for materials which are claimed by the manufacturer to destroy lice, mites, ticks, and other external parasites of poultry when administered to the fowls in feed or water. It was therefore deemed necessary to carry out further experiments, begun last year, to determine whether the chemical compounds usually contained in these so-called remedies or, in fact, any others will destroy or repel such external parasites. Several series of such experiments were carried out during the year. It was found that none of the materials administered to the fowls gave control of such parasites as the chicken lice, chicken mite, scaly-leg mite, fowl tick, and sticktight flea, even though used in large doses. Furthermore, many of the substances administered were deleterious to the fowls.

For several years physicians in the Southeastern States, especially in

Florida, have urged the bureau to undertake an investigation of the human malady known as creeping eruption. An investigator of the bureau undertook preliminary investigations of this common yet little understood affliction during the summer of 1924. The work was carried on in close cooperation with J. L. Kirby-Smith, of Jacksonville, Fla., and the Florida State Board of Health. Substantial progress was made during the summer of 1924 on the epidemiology and treatment of the disease, and numerous specimens were excised from several patients. These specimens were sectioned and given careful microscopic study during the winter, with the result that four specimens of the causative parasite were discovered. These proved to be larval nematodes instead of insect larvæ, as was generally supposed heretofore. Whether insects are concerned in any way with the development and spread of the worm, whether it is a parasite of some higher animal or whether it is a free-living species accidentally attacking man, remain to be determined. A progress report on these studies was presented before the American Medical Association and will be published in the journal of that organization.

The field studies at Mound, La., on the biology, distribution, and seasonal behavior of *Anopheles* mosquitoes were continued. A general report on the types of breeding places found in this locality and the natural conditions affecting mosquito breeding was published, and an investigation of the number of malaria mosquitoes produced per unit of area was completed.

Further tests were made to determine the feasibility of distributing larvicides over large areas by means of airplanes. The final tests made in 1924 were very successful, over 99 per cent of the larvæ in an area of about 40 acres having been destroyed in one of the applications. The dusting of a flooded rice field with a heavy stand of half-grown rice and abundant *Anopheles* breeding demonstrated that the larvæ could be readily killed under these conditions and that such fields were well adapted to airplane treatment. The quantity of Paris green used in places where the protective vegetation was not more than a few feet above the water surface averaged about one-half pound per acre, but the quantity was considerably increased where the water was protected by willows and larger trees.

In May, 1925, *Anopheles* control by airplane was undertaken on a unit in which the breeding areas at the time totaled about 800 acres. This experimental control project was designed to provide data as to the frequency of applications, range of flight of the adults, percentage of control possible, costs of operation, etc.

Several commercial concerns have become interested in the development of improved larvicides and a large number of toxicity tests are being made on these and other materials. Some progress has been made on the production of dry larvicides which have been treated so as to float on the surface of the water.

In chemotropism studies considerable effort has been made to develop a suitable technique for the handling of mosquitoes in such work. The attractive qualities of a series of substances have been tested out, but those tested with *Anopheles* have been almost entirely negative or without effect.

The cooperation with the School of Hygiene, of Johns Hopkins University, on the host preference of *Anopheles* was continued, and a series of mosquito stomachs containing blood was sent to Baltimore for the identification of the blood by means of the precipitin method. In a small number of specimens of *Anopheles punctipennis* no human blood was identified, thus supporting the previous findings with this species.

INVESTIGATIONS OF INSECTS AFFECTING FOREST RESOURCES AND SHADE TREES

F. C. Craighead has continued in charge of these investigations.

One of the more important activities of the year has been the development of closer cooperation with the Forest Service experiment stations. Although funds have not been available for maintaining activities in this field, by restricting certain older projects, entomologists have been detailed to three of these experiment stations during the period of insect activity. It has thus been possible to make considerable advances and initiate certain major projects which later will greatly expedite progress.

DEVELOPMENTS IN COOPERATION WITH THE FOREST SERVICE EXPERIMENT STATIONS

Continued progress has been made at the Lake States Forest Experiment

Station under the direction of S. A. Graham. Reports on certain phases of the spruce budworm and jack-pine sawfly have been published. An important new investigation has been undertaken involving biological studies and the possibilities of control of the serious tip-moth infestation in the Forest Service plantation at Halsey, Nebr. Parasite introduction will be an important feature of this problem. Several thousand parasites, representing 12 or more species, will be liberated.

Cooperation with the Northeastern Forest Experiment Station at Amherst, Mass., was begun late in the year. Certain timberland owners in Massachusetts have donated \$2,500 annually for the next two years for investigations of the white-pine weevil, and R. T. Fisher has offered the facilities of the Harvard Forest at Petersham. Further cooperation is expected from several State forestry departments interested in these studies. The main feature of this problem will be a survey of plantations in second-growth stands from Pennsylvania northward into Canada to determine if possible the factors producing immunity of certain stands. Age, rate of growth, density, species mixtures, site, and location will be some of the factors analyzed. Some time will also be devoted to a study of the entomological aspects of slash (in cooperation with the experiment station and Bureau of Plant Industry) and a study of the larch sawfly.

Field headquarters were established at the Appalachian Forest Experiment Station, Asheville, N. C. E. J. Kraus, of the University of Wisconsin, will devote part of the summer to certain aspects of the work relating to plant physiology. Pine problems, the results of studies of which should be applicable to the coastal plains as well as to the Piedmont region, will receive chief attention. The insects concerned are the bark beetles *Dendroctonus frontalis*, *D. valens*, *Ips avulsus*, *I. grandicollis*, and *I. calligraphus*. The investigations here, which will be of a more detailed character than anything previously undertaken, will consist in an attempt to analyze the environmental factors governing bark-beetle epidemics, and the relation of the condition of the tree itself to bark-beetle attack and brood development, particularly the effects of drought. Several observation stations are being established for comparison of the climatic and soil conditions, sap density, and moisture

content of the trees in two contrasting forest types—one where bark-beetle epidemics originate, the other where bark-beetle outbreaks never occur. This is a joint study involving other projects of the Appalachian experiment station. The part insects play in the death of fire-scorched and turpentine timber and the relation of insects to oak reproduction will also receive some attention in connection with Forest Service studies on other aspects of these problems.

During the winter plans broadening the scope of the western pine bark-beetle investigations were outlined in cooperation with the Forest Service research branch of district 5. These projects involve investigation of the relation of bark-beetle epidemics to various types of forest and timber stands of differing vigor. These studies have as their objective the possibility of improving timber sale regulations so as to reduce losses from bark beetles and secure prevention of losses through good forest management.

INVESTIGATION AND CONTROL OF WESTERN BARK BEETLES

At the western stations the bark-beetle problems have continued to be of the most importance, the chief work consisting of the survey and analysis of the results of large-scale control projects, experimental control on smaller areas, and biological studies. It is more and more evident that each of these destructive species of bark beetles constitutes a problem in itself and that general recommendations applicable to one species may not be suitable for another, or for the same species in a different forest or region. The status of the infestation (i. e., whether epidemic or endemic) likewise affects results. Much progress has been made during the year in gaining a clearer understanding of the possibilities and limitations of control and consequently in improving recommendations to other governmental agencies and private owners.

The San Joaquin project.—This project, initiated in 1919, has now been brought to a close. Direct control measures have been carried on against an endemic infestation of the western pine beetle which was killing annually less than 0.5 per cent of the volume of yellow pine, with the object of determining (1) whether endemic losses of this nature can be reduced, (2) whether increases starting from endemic infestation can be checked or prevented, and (3) whether the stump-

age value of timber saved by such control measures will warrant the cost of the work.

J. M. Miller, in charge, has summarized the results as follows:

1. By working an area with small crews so as to treat the more accessible infested trees it was possible to eliminate from 20 to 50 per cent of the seasonal infestation at a cost of from 4 to 12 cents per acre. This work, however, had little apparent effect in reducing losses or preventing increases.

2. By working an area intensively throughout the season with the object of treating all infested trees it was possible to eliminate about 90 per cent of the seasonal infestation at a cost of from 32 to 45 cents per acre. This method was carried out on a relatively small area of 3,600 acres. The losses were held down to about 48 per cent of what would have occurred if the increase had been in proportion to that on adjoining check areas where no work was done.

3. Intensive maintenance work is apparently the only method that will secure results, but in order for the cost of such work to be warranted by the value of the timber saved stumpage values will have to range from \$7 to \$12 per thousand. As present values on this area are about \$3 per thousand, the work was carried on at a loss. There are certain intangible benefits to be reckoned, such as added fire protection and elimination of snags, but under present values it can not be claimed that these additional benefits are sufficient to compensate for the loss on the control work.

These results will modify the policy that has been previously advocated in the control of this beetle. Heretofore control work has been considered warranted if directed against an infestation in accessible timber when any aggressive tendencies were noticeable, even though losses were low. Unless less expensive methods can be evolved control work under present stumpage values of yellow pine in this district can not be applied to advantage except where relatively high epidemic losses prevail. With losses as high as 1 per cent of the stand and stumpage values in excess of \$3.50 per thousand, a saving can be effected by direct control methods.

The southern Oregon-northern California project.—Results in controlling epidemic infestations are more promising and economically justifiable as exemplified by the southern Oregon-northern California project. The three-year program directed toward the control of the western pine beetle over this area of 1,000,000 acres, which was started in 1921, was brought to a close in 1924. This work was carried out cooperatively by the Forest Service, the Indian Service, and over a thousand private owners under the technical supervision of this bureau. Before the project was started the

western pine beetle was found to be destroying 120,000,000 board feet of merchantable yellow pine each year, having killed 10 per cent of the stand in the last 10 years. During the period of the work 32,000 yellow-pine trees containing 35,000,000 board feet of merchantable lumber, which had been killed by the beetles and still contained the live broods, were felled and the broods destroyed by burning the bark. The total cost of this work was \$145,000. A recent survey shows that since the control work started the annual timber loss has been reduced by 50,000,000 board feet per year which, at the present value of stumpage in this region, means an annual saving of from \$150,000 to \$200,000. To prevent recurring epidemics of the western pine beetle continued watchfulness must be maintained and control measures instituted whenever the beetle shows signs of assuming an epidemic status.

The Kaibab control project.—This project, directed toward the control of the Black Hills beetle on the Kaibab Plateau in northern Arizona, was continued during the year in cooperation with the Forest Service and National Park Service. This outbreak, first noticed in 1920, increased in severity during the next few years, destroying 25,000,000 board feet in the season of 1923 alone. In 1924 \$35,000 was spent on the national forest and the Grand Canyon National Park in the control of this insect. Over 28,000 trees which had been killed by the beetles were treated. A survey made in the fall of 1924 showed that this represented less than half of the infested trees, but where the control work was instituted the progress of the infestation was halted, at least temporarily, and considerable timber saved from destruction. On these treated areas a reduction in infestation of 50 per cent was obtained. This was lower than was anticipated and probably the almost rainless summer greatly influenced the results. This project will be continued for another year at least.

The Deerlodge and Bitterroot National Forests, Mont.—The Forest Service and Bureau of Entomology have agreed on tentative plans for conducting a large-scale project against the mountain pine beetle in an effort to protect the valuable lodgepole stands in the Deerlodge and Bitterroot National Forests in Montana. An outbreak developing in the Clearwater drainage in 1909 has been continuously progressing ever

since in out-of-the-way regions. The total quantity of timber killed has been enormous, but since it was largely inaccessible it was felt that control measures were not warranted. This infestation has now crossed to the east side of the Continental Divide on the above-mentioned forests and merchantable timber is threatened. Some \$6,000 will be spent this year and the operations will be enlarged next season. Besides the protection obtained, this project will yield valuable data regarding this insect and the technique in fighting it.

AIRPLANES USED IN BARK-BEETLE SURVEYS

During the latter part of the year tests were made to determine the practicability of using airplanes in locating bark beetle-infested trees on the national forests. Through cooperation of the War Department a plane was dispatched from Crissy Field, San Francisco, Calif., to certain bark beetle-infested areas on the Sierra National Forest. An observer was carried and photographs taken of nearly 20 square miles of timberland. A much clearer idea of the distribution of the infestation was obtained and the infested trees were readily located on the prints obtained. The preliminary results are very encouraging, but further tests will be needed before the practicability of this method in comparison with the laborious ground surveys can be fully determined. If the costs are not excessive it promises great advantages.

ENTOMOLOGICAL ASPECTS OF SLASH DISPOSAL

This important question has received continued attention and the results of several years' experiments and general studies in Oregon and California have been compiled for publication. It has been demonstrated that pine slash in this region is not a menace to surrounding timber in affording breeding material for the multiplication of injurious bark beetles. This is due to the high mortality of the developing broods.

INTERRELATION OF INSECTS AND FIRE

The results of these studies will be submitted for publication by the department in the near future. Contrary to the generally prevailing opinion, it has been found that, although fires in the yellow-pine forests of California do concentrate bark beetles on the area and thus increase losses, they do not serve as centers for building up infestations.

DEFOLIATING INSECTS

The most important outbreaks of defoliating insects occurred in the Yellowstone National Park. A new species of sawfly and a needle tyer, *Argyrotaenia* (*Eulia*) *pinitubana* Kearfoot, were involved which together have killed some 25 square miles of lodgepole pine. A lighter infestation exists over an area of 100 square miles. No wholesale control methods were possible, but along one of the main highways crossing this belt arsenical sprays were used with excellent results. The spruce budworm infestation still continues in the Yellowstone National Park and now threatens an area of great scenic value visited by large numbers of tourists. Experimental spraying will be conducted in the hope of at least saving roadside trees and those about camping grounds. Several square miles of Douglas fir have already been completely killed. Studies on the Monterey sawfly have continued. The present distribution of the Pandora moth in Oregon and California has been definitely determined. The defoliated area in Oregon covers approximately 300,000 acres, resulting in a serious reduction of the timber resources of the region. In epidemic centers the trees are almost entirely stripped of their foliage. This evidently lowers the resistance of the trees, with the result that they become an easy prey to bark beetles. The losses from this combined attack on a portion of the area has, within the last two years, increased from a negligible quantity to 10 per cent of the stand.

THE EUROPEAN PINE-SHOOT MOTH

During the spring of 1925 another survey was made to determine the present status of the European pine-shoot moth. This insect, which has been regarded as one of the most serious forest pests in Europe, has been established in this country for 12 or 13 years. In 1914 its status in the United States was thoroughly investigated, and recent examinations indicate little change in the situation. It is still present on certain private estates and nurseries in New York and Connecticut, but no evidence indicating its spread to natural pine stands has been found. The owners of these infested trees are cooperating in control. There is a serious potential menace in this situation, and steps are being taken to prevent the insect from becoming established in native timber stands.

TIMBER LOSSES IN THE SOUTHERN PINE BELT

Toward the end of the extreme drought which occurred over portions of eastern Texas, Louisiana, and Mississippi in the summer and fall of 1924 numerous reports were received describing quantities of dying pine infested with bark beetles. Expert investigation showed that over 100,000,000 feet of longleaf and loblolly pine was dead or dying, attacked by several species of *Ips*. It was finally concluded that the unusual drought was the primary cause of this mortality, though the losses were possibly increased by the attack of these beetles. Observations in the spring and summer after the resumption of nearly normal precipitation showed the situation relieved and the bureau's conclusions justified. Turpentine interests in this region were greatly concerned, owing to the extremely heavy losses in the timber which they were operating. The bureau's recommendations urging prompt salvage of the infested trees and advising against direct-control operations undoubtedly saved thousands of dollars.

INSECTS AFFECTING FOREST PRODUCTS

Tests of wood preservatives for both crude and finished forest products, as well as poisons for wood-pulp products, have been continued, both at Falls Church, Va., and on Barro Colorado Island, Canal Zone, Panama, by T. E. Snyder. Several coal-tar oils, sodium fluoride and other salts, various metal sprays, etc., are recent additions to these tests. An inspection of the tests located at Falls Church, Va., after 12 years' service, indicated that a coal-tar creosote with a high naphthalene and normal tar-acid content was more effective than one with normal naphthalene and high tar-acid content. The "full-cell" cylinder pressure process with such a coal-tar creosote is the most effective treatment so far tested for wood in contact with the ground. A lively interest is being manifested in these tests of wood preservatives by commercial firms in the United States as well as in other parts of the world. Officials of the Army, Navy, and aircraft services have recently sought this bureau's cooperation in efforts to clean up hardwood stock damaged by *Lyctus* powder-post beetles at their storage depots. Assistance has also been requested in writing out specifications for the future purchase of hardwood stock, by

following which such damage will be prevented. The Ordnance Division of the War Department in the future will insist on a linseed-oil treatment for implement-handle stock. Special efforts have been made to induce city engineers to modify building regulations slightly, so that damage by termites will be prevented. Approximately 150 requests per year are received from all over the United States for assistance in remedying termite damage to buildings and their contents; of course, this represents only a small proportion of the actual damage. In the experiments conducted in cooperation with the Bureau of Standards in spraying metals on wood infested with the California lead-cable borer all of the metal coatings except copper and brass were penetrated. The factor of hardness of the coating that resulted from the spray did not seem to be the determining element of effectiveness against this borer.

A moving picture entitled "Board feet or bored timber" has been taken by the motion-picture laboratory of the department. The use of this film, and the publication of an illustrated manuscript just completed describing various types of insect defects in wood and methods of preventing them, should be of great educational value and help to manufacturers and should result in the prevention of some of the \$40,000,000 annual loss by insects to forest products.

Studies of the biology and classification of termites, particularly American species, have been continued and extensive additions made to the collection which is now one of the best in the United States.

INSECTS AFFECTING SHADE TREES AND HARDY SHRUBS

The demand for information on insects of this class continues to increase, requiring further concentration on disseminating information. However, some experimental work has been conducted on the control of the boxwood leaf miner and the introduction of a dipterous parasite (*Erynnia nitida*) of the elm leaf beetle, from France, has been attempted. A general survey by questionnaires was made to determine the susceptibility of various tree species to insect injury in the different regions of the United States. Information on the insects affecting bamboo in the United States was brought together and published as a part of Department Bulletin 1329.

BEE CULTURE INVESTIGATIONS

The work of the bee-culture laboratory, under the supervision of James I. Hambleton, has been continued along the same general lines as formerly. The laboratory and experimental apiary are located at Somerset, Md., near Washington.

BEHAVIOR OF BEES

The brood-rearing work begun in 1921 is still being continued on one colony to determine the longevity and the lifetime brood-rearing activity of an individual queenbee under normal apiary conditions. Department Bulletin 1349, based on data obtained in 1921, is in press. The necessarily slow work of computing the later data obtained is progressing satisfactorily.

During the present season active experimental work on queen rearing has been taken up and a method has been devised for introducing queen cells and having them accepted with the expenditure of less labor and with fewer bees per cell than is the case with certain methods now commonly used. The perfection of this method should result in the production of queenbees at considerably reduced cost.

The investigation of the responses of colony activity to changes in external temperature, humidity, and other factors, begun in the summer of 1921, was continued during the months of May and June, under artificial honey-flow conditions, and constituted a check on previous work. It is hoped that sufficient data are now at hand to complete this investigation. These data are now being computed.

A sequel to an investigation completed last year, the results of which will shortly appear as Department Bulletin 1339, "The Effect of Weather Upon the Change in Weight of a Colony of Bees During the Honey Flow," was conducted during the months of May and June at a temporary station established on the Delaware coast. This investigation dealt primarily with the effect of weather factors upon the flight activities of the honeybee. The data obtained are now being computed. The work was conducted with the cooperation of the United States Coast Guard.

Experiments are being made to ascertain the reactions of bees to intensities and colors of light. Previous work of this nature has not taken the intensity of color sufficiently into account to determine positively whether bees see colors as normal humans or as color-blind humans. In this in-

vestigation an attempt has been made to cause bees to associate intensity of light with food. Thus far results have been largely negative. The use of different colors has not yet been tried. These experiments should throw some light on the old question of the relation of flower colors to insect visits, and also upon methods for the successful lighting of bee cellars.

Department Bulletin 1328, "The Flight Activities of the Honeybee," has appeared during the year and has been the cause of much comment, as it was found that the amount of work performed by the individual bee is much less than was commonly supposed.

The study of the colors of American honeys, begun in 1922 in cooperation with the Bureau of Agricultural Economics, has been continued during the present season. In the last annual report mention is made of a number of difficulties encountered in perfecting a satisfactory grader, based on the color analyses of several hundred American honeys, but attention was called to the fact that all the difficulties had apparently been overcome and that an announcement of the perfection of a satisfactory grader was shortly expected. Since that time other difficulties have been encountered, the principal one being to find a medium of permanency to carry the correct color and turbidity of honey.

Finally, in cooperation with A. H. Pfund, of Johns Hopkins University, a satisfactory grader has been perfected which embodies all of the features desired in a honey-color grader. The principal feature of this grader is a wedge-shaped vessel for containing the sample of honey to be analyzed, combined with an inversely placed wedge of amber glass. The two wedges are viewed simultaneously through a slit by means of light transmitted from the rear. When the color of the honey and that of the glass wedge match, the color grade of the honey is indicated on an appropriate scale calibrated for the commercial grades of extracted honey to be recommended as standard for the United States by the Bureau of Agricultural Economics. The principles upon which the grader is founded have been patented by Doctor Pfund.

The cost of the grader is high, especially to the small beekeeper, and this fact is to be regretted, but it will nevertheless give the beekeeping industry a reliable and permanent instrument for grading the color of

honey. It will also serve as a standard for calibrating cheaper and more temporary graders.

PHYSIOLOGY OF BEES

The work started last year on the utilization of carbohydrates by honeybee larvæ has been completed. It was found that larvæ derived nourishment from the following carbohydrates listed in the order of their apparent value as food for the larvæ: Sucrose, levulose, melezitose, dextrose, trehalose, dextrin, galactose, and lactose. They received no nourishment from starch or glycogen.

A small but fairly satisfactory chemical laboratory has been equipped for making a study of the digestion and physiology of the honeybee. A research has been started to ascertain what becomes of nitrogen and fat in the body of the worker bee during the winter period of partial inactivity, and a number of preliminary analyses have been made. The mortality of adult bees during the winter months is large over the entire United States and amounts annually to at least 10 per cent of all bees. Although this loss can not be attributed to any one cause, the evidence is strong that the kind of winter stores is largely to blame.

DISEASES OF BEES

Experiments have been made with various materials having the requisite properties for disinfecting combs infected with *Bacillus larvae*, the causative organism of American foulbrood, with special attention to a solution of formaldehyde and water. There is at present on the market a commercial disinfecting solution which is satisfactory for this purpose, but it is expensive and difficult for the beekeepers to procure, and it is hoped that, as a result of experiments, a cheaper and more efficient material will be found. Already a manuscript has been prepared dealing with the bacteriological phase of the effect of a water-formaldehyde solution upon the spores and vegetative forms of *Bacillus larvae*. These tests indicate that this solution, bacteriologically, is as efficient as the commercial solution, but it lacks somewhat in penetrating power. Before an unconditional recommendation could safely be made for the use of this material it was deemed well to test the solution under actual apiary practice. Through the kindness of H. L. Kelly, a local beekeeper, this has been made possible, with the result that over 1,500 infected frames have been

treated. Preliminary data indicate that the solution will prove satisfactory.

There is now considerable discussion as to the part that commercial shipments of honey play in disseminating American foulbrood. This is a very important subject, especially in view of the fact that there is a movement on foot to attempt a country-wide eradication of this disease, which is continually threatening the beekeeping industry in many parts of the United States. Honey in commerce, as a carrier of bee diseases, is being investigated.

In the bee-disease routine work 781 samples have been diagnosed, with the following result: American foulbrood 296, European foulbrood 117, sacbrood 36, mixed infection 3, cultures of treated comb 42, adult bees 175, miscellaneous 112. Twenty of the samples of adult bees were examined for the presence of arsenic, and 11 of these were found to contain enough arsenic to account for the death of the bees; 58 showed the presence of *Nosema apis* spores, and 117 were negative.

Fifty-seven foreign queenbees and their attendant workers were imported into the United States from the following countries: Carniola, Transcaucasia, Austria, Rumania, Italy, Holland, Germany, Switzerland, and Algeria. All of these importations were free of the mite *Acarapis woodi*, the cause of Isle of Wight disease, which is common and widespread in Europe. The mite has not been found in this country in a four-year examination of samples from all parts of the United States. About half of the foreign importations contained spores of *Nosema apis*.

The work on the relation of fungi to the honeybee has been continued. Collections have been made of various forms of fungi, but the greater share of the time has been spent on species of *Aspergillus*. Two species with their related strains have been found to be virulent parasites of adult bees and of brood in all stages. One of these organisms, previously unknown in this country, which causes a disease known as stone brood in Europe, has been found on several occasions.

Beekeepers have been complaining for many years of the abnormal death of adult bees. Upon examination nothing could be found which would account for these conditions. The bees before death have varied so much in their reactions that a number of specific names have arisen, such as "May

disease," "June disease," "disappearing disease," "paralysis," and others. Several of the symptoms in bees supposedly suffering from some of the foregoing so-called mysterious diseases have been produced in the laboratory at will and it is hoped that the mystery surrounding some of the diseases of adult bees will eventually be cleared.

BEEKEEPING REGIONS IN THE UNITED STATES

Lack of funds has hampered work on this subject, although information on the best methods of beekeeping suitable to the various parts of the country has been accumulating. There is real need for more specific recommendations for beekeeping practice in several of the beekeeping regions where the potential possibilities for developing the industry are great. This is especially true throughout sections of the South and Southeast and in the irrigated sections of the West and Northwest. It is hoped that more active work in the field can be started next year.

DEMONSTRATIONS IN BEEKEEPING

Little active work has been done in the field on this project, as lack of funds prevents maintaining any representatives of this office in the field. Despite this handicap, the office has aimed to keep in as close contact with the beekeepers as possible, this having been done largely through correspondence. Members of the staff have attended 19 meetings held in 11 States. Four of these meetings were short courses. Many requests to assist in beekeepers' meetings and demonstrations in all parts of the country were received, but attendance at only a limited number was possible because of lack of funds, and no meeting was participated in west of the Mississippi River.

MISCELLANEOUS ACTIVITIES

The correspondence of the office has been heavier this year than at any previous time since the war, when the activities of the office were greatly augmented. This seems to indicate that the beekeepers of the country continue to be interested in the work of this office and have confidence in it.

INSECT PEST SURVEY

The work of the Insect Pest Survey has been carried on, as in the past,

under the direction of J. A. Hyslop. The survey has now functioned for four years and is recognized as an integral part of the cooperative work of the bureau and the entomological agencies existing in the several States and the Dominion of Canada.

In 1924 the survey completed volume 4 of its monthly bulletins, consisting of 8 numbers and 327 pages of text material and an index of 36 pages. Nos. 1 to 4 of volume 5 were also issued during the last fiscal year, comprising 222 pages of text material. Urgent matter was handled in the form of special reports as heretofore.

The work on a common-name index, instigated by the survey and assumed by the American Association of Economic Entomologists, has resulted in the publication of a list of common names approved by the working entomologists throughout the country for general use. Subsequent appendixes are proposed as common names become necessary for additional species.

The technical paper on the correlation of climatic conditions with the abundance of the chinch bug throughout that part of the United States where this pest was a serious factor from the years 1870 to 1920, inclusive, is still in manuscript form and in all probability will be completed during the coming year. The delay in the completion of this paper was made necessary by the ever-increasing mass of material which the survey is handling.

The survey is now working on a project to incorporate in its files all the statistical data on economic insects of North America which have been published in the past. This of course will take many years, but when completed will make available the greatest mass of statistical information on insects extant. Work on an atlas of economic insects, started during the first years of the survey, has been temporarily suspended owing to lack of technical help. The survey's files now contain references to over 1,800 different species of insects reported as of more or less economic importance. These insects represent practically all of the major orders and fall into 1,194 genera.

The work of the survey has now reached a point where further expansion is impossible without technical assistance. Within the coming year this will probably be forthcoming.

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